POWERS' ROAD AND STREET CATALOG AND DATA BOOK 1934

100 PAGES OF MACHINERY PICTORIALS - 936-136 (935 INDEX MACHINERY MANUFACTURERS)

Q-67
1934
$35.00

P.90 INTERNATIONAL HARVESTER

P.90 MODELS

Digitized by



ASSOCIATION
FOR
PRESERVATION
TECHNOLOGY,
INTERNATIONAL
www.apti.org

BUILDING
TECHNOLOGY
HERITAGE
LIBRARY

https://archive.org/details/buildingtechnologyheritagelibrary

From the collection of:

Mike Jackson, FAIA

POWERS' ROAD AND STREET CATALOG AND DATA BOOK

1934

A Consolidation of Manufacturers' Catalogs of Highway, Road and Street, Construction, Plant and Maintenance Equipment.

Together with a Data Section of Engineering Information and Economic Methods on the Design, Construction and Maintenance of Highways, Roads and Streets, Compiled and Edited Under the Direction of Halbert P. Gillette, Editor of Roads and Streets, Author of Handbook of Cost Data and Handbook of Construction Costs.

TENTH ANNUAL EDITION

Copyright 1934

GILLETTE PUBLISHING CO.
400 WEST MADISON STREET
CHICAGO, ILLINOIS

FOREWORD

THIS is the tenth (1934) edition of the Powers' Road and Street Catalog and Data Book, presented by the Gillette Publishing Company for the use of those engaged in the construction, maintenance and operation of public streets and highways.

This edition contains condensed catalog data of leading manufacturers of highway machinery, equipment and materials; a comprehensive engineering data section devoted to the design, construction and maintenance of highways, roads and streets; and a directory of Federal, State and County Highway Department Officials and Engineers.

The Data Section has been revised under the supervision of Mr. Halbert P. Gillette and is the equivalent of a 500-page handbook of road and street data. All specifications have been brought up to date, and data on a number of new subjects have been added.

The combination of Data Section, the manufacturers' catalog pages and the various directories of the associations and individuals actively engaged in the Highway Industry makes this a very complete and practical reference work.

Since this Catalog is primarily dedicated to the service of its users, we invite a close scrutiny of its contents and will welcome constructive criticism or suggestions which will enable us to make future editions of even greater value.

GENERAL INDEX

Advertisers' Section 33-140

Classified Directory (by-products) of Manufacturers 10-28

Data Section 175-268

Distributors' Section 29-32

Highway Industry Section 141-174

- American Association of State Highway Officials 146-147
- American Road Builders' Association 142-144
- Associated General Contractors 145
- Bureau of Public Roads 148
- Federal, State and County Highway Departments 149-174

Index to Advertisers' Section 6-7

Index to Data Section 8-9

ADVERTISERS' INDEX

A

Adams Company, J. D. 36-37-38-39
Allis-Chalmers Tractor Division 40-41
American Steel & Wire Company 42-43
Atlantic Refining Company, The 45
Austin-Western Road Machinery Co., The 46-47-48-49-50-51-52-53-54-55

B

Barrett Company, The 56-57
Blaw-Knox Company 58-59
Bucyrus-Erie Company 60
Burch Corporation, The 61

C

Calcium Chloride Association 62-63
Carey Company, The Philip 64
C. H. & E. Manufacturing Co., Inc. 65
Chicago Tubing & Braiding Co. 66
Cleaver-Brooks Co. 67
Cleveland Tractor Company, The 68-69
Columbia Alkali Corporation, The 62-63
Continental Roll & Steel Foundry Company 70
Curtis Pneumatic Machinery Company 71

D

Day Pulverizer Co., Inc. 72
Dow Chemical Company, The 62-63

E

Eagle-Picher Lead Company, The 73
Etnyre & Company, E. D. 74

F

Fairbanks, Morse & Co. 75
Flexible Road Joint Machine Company 76

G

Galion Iron Works & Mfg. Co., The 77-78
Gillette Publishing Company 65-67-76-79-88-100-115-122
Good Roads Machinery Corp. 79
Grasselli Chemical Company, The 80

H

Harnischfeger Corporation 81
Hauck Manufacturing Company 82
Heltzel Steel Form and Iron Company 83
Hercules Motors Corporation 84
Hercules Powder Company 85
Highway Steel Products Company 86
Honhorst Co., The Jos. 87

I

Industrial Brownhoist Corp. 88
Ingersoll-Rand 89
International Harvester Company 90-91-92-93

ADVERTISERS' INDEX (Continued)

J

Jahn Company, C. R. 94
Johns-Manville 95

K

Kalman Steel Corporation 96

L

Leschen & Sons Rope Company, A. 97
Link-Belt Company 98-99

M

Macasphalt Corporation of America 100
Metal Forms Corporation 101-102
Mexican Petroleum Corporation 103
Michigan Alkali Company ..... -62-63

N

National Carbide Sales Corporation 104
National Paving Brick Association 105
Norma-Hoffmann Bearings Corporation 106

P

Page Steel and Wire Company 107
Portland Cement Association 108

R

Riddell Company, W. A. 109
Roads and Streets 44-136
Robeson Process Company 110

S

Sauerman Bros., Inc. 111
Servicised Products Corporation 112-113-114
Smith Company, The T. L. 116
Solvay Sales Corporation 62-63
Southern Wood Preserving Co. 117
Standard Oil Company (Indiana) 118-119
Standard Oil Co. of New York, Inc. 120-121
Sullivan Machinery Company 123

T

Texas Company, The 124-125
Timken Roller Bearing Company, The 126
Toledo Pressed Steel Co., The 127
Toncan Culvert Manufacturers' Association 128-129
Toro Manufacturing Co. 130
Truscon Steel Company 131
Tuthill Highway Guard 132

U

United States Pipe and Foundry Co. 133
Universal Crusher Company 134

Z

Zaremba Snow Rooters 135

DATA SECTION

Table of Contents

A

Aggregate for Use with Tar Binder, Table of Quantities..... 216
Aggregate, Slag 205
Aggregate, Weight of..... 216
American Association of State Highway Officials, List of Materials Specifications 256
American Association of State Highway Officials, Specifications for Bridges and Incidental Structures, Reference 255
American Society for Testing Materials, List of Specifications Applicable to Road and Street Work.252, 255
Asphalt, Emulsified, in Coarse Aggregate Pavement Construction....223, 225
Asphalt Wearing Courses and Foundations, Approximate Quantities of Materials Required for..... 221
Asphaltic Concrete, Approximate Quantities of Materials Required for 221
Asphaltic Emulsion, Specifications.... 223
Asphaltic Road Materials, Specifications for 217, 219
Asphaltic Surface Treatment of Natural Soils 213, 216

B

Binder, Tar, Quantities of Aggregate for Use With..... 216
Bituminous Macadam Surface Course, Specifications 220, 221
Bituminous Pavement Sections, Rhode Island Board of Public Roads..... 212
Bituminous Surface Course Construction in New Mexico, Costs..... 222
Bituminous Surface, Reinforcement with Cotton Fabric 250
Bituminous Surface Treatment of Natural Soils 213, 216
Bituminous Surface Treatment, Specifications 225
Blade and Cast In Work, Specifications 179
Blade Grader, Methods and Cost.180, 181
Blasting 182, 186
Block Pavement, Miscellaneous, Specifications 211
Borrow, Specifications 178
Brick, Standard, Sizes, Weights and Quantities 207
Brick Pavement Construction, Methods of Removing Surplus Filler..... 208
Brick Pavement Cross Sections..... 209
Brick Pavement Filler..... 207
Brick Pavement, Quantities, Specifications, and Costs 207
Brick, Resurfacing with.....209, 210
Bridges and Incidental Structures, Specifications, Reference..... 255
Bridges and Structures, Timber, Specifications 238, 239
Broom—Drag for Finishing Surface... 224

C

Cable Guard Rail, Specifications.... 236
Calcium Chloride in Cold Weather Construction 206
Calcium Chloride, Stabilization of Low Cost Roads with.....190, 191
Calcium Chloride, Use in Maintaining Gravel and Macadam Roads..... 189
Cement Bound Macadam Pavement, Specification 203, 204
Clay-Sand Surface, Specifications.187, 188
Cleaning Streets at Toronto, Ontario. 243
Clearing, Specifications 178
Climate, Weather Conditions and Working Days 229, 230
Coal Tar—See Tar
Cold Weather Concrete Pavement Construction, Precautions 205, 206
Concrete, Asphaltic, Approximate Quantities of Material Required for 221
Concrete, High Early Strength..... 206
Concrete Paving, Water Required for 233
Concrete Pavement Construction in Cold Weather, Precautions....205, 206
Concrete Pavements, Cross Section and Quantities 195
Concrete Pavements, Materials Required per Linear Foot, per Mile, and per Cubic Yard for Various Cross Sections 195
Concrete Pavements, Typical Cross Sections of Various States.....196, 197
Concrete Road Specifications, Charted Summary for All States.....199, 202
Contract Terms, Definitions of.... 265
Cotton Fabric Reinforcement for Road Surfacing 250
Cross Sections, Bituminous Pavement, Rhode Island Board of Public Roads 212
Cross Sections of Concrete Pavements 195, 197
Cross Sections, for Grading, Minnesota State Highway Department... 187
Cross Sections of Resurfaced Brick Pavement 209
Crushed Stone and Screenings for Waterbound Macadam Base and Surface Courses, Specifications..... 193
Crushed Stone, Cubic Feet per Ton.. 194
Crushed Stone Surface Course, Traffic Bound, Specifications..... 188
Crushed Stone, Table of Spread in Waterbound Macadam..... 194
Crushed Stone for Traffic Bound Surface Courses, Specifications..... 188
Crushed Stone, Weight of.....194, 216
Curbing, Concrete, Specifications.... 242
Curbing, Stone, Specifications..... 211

D

Definitions of Contract Terms..... 265
Definitions of Copyrighted Names and Patented Types of Pavements...266, 268
Definitions of Terms Used in Road and Street Work.....257, 265
Drag—Broom for Finishing Surface.. 224

E

Earth Surface, Oiled, Specifications.. 226
Economics—Relation of Traffic Volume to Degree of Improvement..... 212
Embankment, Settlement of, Specifications 177
Embankment, Settling with Explosives 185, 186
Embankment, Specifications 177
Employment on Public Roads in 1933. 191
Emulsified Asphalt in Coarse Aggregate Pavement Construction...223, 225
Emulsion, Asphaltic, Specifications... 223
Excavation, Specifications 176
Explosives in Road Work.....182, 186
Explosives, Settling Fills with.....185, 186

F

Fabric, Wire Guard, Specifications.. 237
Federal Standard Stock Catalog Specifications, List of Items Applicable to Road and Street Work..... 251
Fill—See Embankment
Fill, Settling with Explosives.....185, 186
Filler in Brick Pavement Construction, Methods of Removing Surplus..... 208
Filler for Brick Pavement, Quantities and Specifications 207
Filler for Crushed Stone Macadam Bottom Course 194
Float, Longitudinal, in Concrete Road Construction 206
Friction in Steel Pipe, Loss of Head Due to 233

G

Glossary of Terms Used in Road and Street Work 257, 265
Glossary of Copyrighted Names and Patented Types of Pavements...266, 268
Grading, Blade and Cast in Work, Specifications 179
Grading with Blade Grader, Methods and Costs 180, 181
Grading, Explosives in.....182, 186
Grading, Roadway and Drainage Excavation, Specifications..... 176
Grading Sections, Minnesota State Highway Department 187
Grading, Settlement of Embankment, Specifications 177
Grading, Specifications for Borrow... 178
Grading, Specifications for Embankment 177
Gravel or Crushed Stone Surface Course, Traffic Bound, Specifications 188
Gravel and Macadam Roads, Use of Calcium Chloride in Maintenance. 189
Gravel, Pounds per Cubic Yard..... 179
Gravel Road Material, Basis of Quality 179
Gravel Surface Course, Specifications 194
Grubbing, Specifications 178
Guard Rails, Descriptions and Specifications 234, 237
Guide Posts, Specifications..... 244

H

Head, Friction Loss in Steel Pipes.... 233
High Early Strength Concrete..... 206
Hydraulic Data and Tables.....231, 233

I

Illumination of Streets and Highways, Recommendations, I.E.S. Code.240, 241

L

Lighting of Streets and Highways, Recommendations of I.E.S. Code 240, 241
Limestone, Weight of..... 216
Low-Cost Roads, Laboratory Traffic Test for 229
Low Cost Roads, Stabilization with Calcium Chloride 190, 191

M

Macadam, Asphalt Base, Approximate Quantities of Materials Required for 221
Macadam Base Course, Water Bound, Specifications 192
Macadam Base and Surface Courses, Specifications for Crushed Stone and Screenings 193
Macadam, Bituminous, Surface Course, Specifications 220, 221

DATA SECTION—Continued

Macadam, Calcium Chloride in Maintenance of 189
Macadam, Cement Bound, Specification 203, 204
Macadam, Filler Required for Crushed Stone Bottom Course..... 194
Macadam, Quantities for Estimating Purposes 194
Macadam Surface Course, Waterbound, Specifications 193
Macadam, Table of Weights and Spread of Stone..... 194
Maintenance Costs 243
Maintenance, Cost Analysis of Snow Removal in Michigan.....245, 247
Maintenance of Gravel and Macadam Roads by Use of Calcium Chloride. 189
Maintenance, Snow Removal Methods and Costs in Various States....247, 250
Maintenance, Specifications and Contract Procedure for Snow Removal. 244
Markers, Road, Specifications..... 244
Materials, National Directory of Commodity Specifications, Reference... 251
Materials Supply, Sources Listed by National Bureau of Standards..... 251
Mortar Required for Vitrified Pipe... 229

N

Names of Patented Types of Pavements 266, 268
Names of Pavements, Copyrighted.266, 268
National Directory of Commodity Specifications, Reference 251
Natural Soils, Surface Treatment of 213-216
Nozzles, Table of Discharge..... 231

O

Oil, "PO," Specifications..... 226
Oiled Earth Surface, Specifications.. 226

P

Paint, White Traffic Zone, Specifications 241
Patented Types and Copyrighted Names of Pavements.....266, 268
Pavements, Patented Types and Copyrighted Names 266, 268
Paving Brick, Standard Sizes, Weights, and Quantities 207
Piles, Timber 238
Pipe Discharge Table..... 231
Pipe, Iron or Steel, Weights per Foot 231
Pipe, Loss of Head Due to Friction.. 233
Pipe, Pressures Required at Pump for Various Rates of Discharge per Mile of Pipe 232
Pipe, Size and Capacity..... 231
Pipe, Table of Friction Heads..... 231
Pipe, Vitrified, Table of Weights per Foot and Mortar Required..... 229
Plans and Specifications, Intent..... 268
Posts, Guide, Specifications..... 244
Precautions for Concrete Pavement Construction in Cold Weather..205, 206
Preservative Treatment of Timber.... 239
Pressures Required at Pump for Various Rates of Discharge per Mile of Pipe 232
Pumping Data, How to Determine Power Required 231
Pumping Pressure Required for Various Rates of Discharge per Mile of Pipe 232

R

Rails, Guard 234, 237
Resurfacing with Brick.....209, 210
Re-Tread Developments in 1933..... 227
Road Markers, Specifications..... 244
Roadside Trees, Care in California... 186
Roadway Cross Sections, Minnesota State Highway Department..... 187
Roadway and Drainage Excavation, Specifications 176

S

Sand-Clay Surface, Specifications.187, 188
Sand, Pounds per Cubic Yard..... 179
Screenings per Mile of Road..... 179
Screenings for Waterbound Base and Surface Courses, Specifications.... 193
Sections of Pavement—See Cross Sections
Settlement of Embankment, Specifications 177
Settling Fills with Explosives.....185, 186
Sheet Asphalt, Approximate Quantities of Materials Required for..... 221
Sheet Asphalt, Protection of..... 228
Slag As an Aggregate for Concrete.. 205
Snow Removal Methods and Costs in Various States.....247, 250
Snow Removal in Michigan, Cost Analysis of 245, 247
Snow Removal in Ontario, Specifications and Contract Procedure..... 244
Specifications of the American Association of State Highway Officials, List of 256
Specifications of the American Society for Testing Materials, List of...252, 255
Specifications, Concrete Road, Charted Summary for All States.....199, 202
Specifications, List of Federal Standard Stock Catalog Specifications Applicable to Road and Street Work 251
Specifications of National Societies and Associations, General References 255
Specifications, National Directory of Commodity, Reference 251
Specifications for Bridges and Incidental Structures, A.A.S.H.O., Reference 255
Specifications Quoted—
Roadway and Drainage Excavation. 176
Embankment 177
Settlement of Embankment..... 177
Clearing 178
Grubbing 178
Borrow 178
Blade and Cast In Work..... 179
Sand-Clay Surface..... 187
Traffic Bound Gravel or Crushed Stone Surface Course..... 188
Waterbound Macadam Base Course 192
Waterbound Macadam Surface Course 193
Crushed Stone and Screenings for Waterbound Macadam 193
Gravel Surface Course..... 194
Cement Bound Macadam..... 203
Brick Pavement 207
Miscellaneous Block Pavement..... 211
Stone Curbing 211
Liquid Asphaltic Road Materials.217, 219
Bituminous Macadam Surface Course 220, 221
Bituminous Surface Treatment..... 225
Oiled Earth Surface..... 226
Road Oil "PO"..... 226
Wood Guard Rails..... 235
Cable, Guard Rails..... 236
Wire Guard Fabric..... 237
Timber Highway Bridges and Structures 238, 239
Lighting of Streets and Highways 240, 241
White Traffic Zone Paint..... 241
Concrete Curbing 242
Guide Posts 244
Road Markers 244
Snow Removal 244
Stabilization of Low Cost Roads with Calcium Chloride 190, 191
Stone Block Pavement, Miscellaneous, Specifications 211
Stone, Crushed, for Waterbound Macadam Base and Surface Courses.. 193
Stone Curbing, Specifications..... 211
Stump Blasting 182
Surface Maintenance Costs..... 243
Surface Treatment, Bituminous, Specifications 225
Surface Treatment of Natural Soils.213, 216
Surface Treatment, Oil, Specifications 226
Surface Treatment, Tar..... 219
Surface Treatment, Tar, Developments in 1933 .....227, 228

T

Tar Binder, Quantities of Aggregate for Use with 216
Tar for Highways, Developments in the Use of in 1933.....227, 228
Tar for Highway Use, Suggested Grades 228
Tar Re-Tread, Developments in 1933.. 227
Tar Surface Treatment..... 219
Tar for Surface Treatment, Specifications 225
Tile Pipe, Table of Weights per Foot and Mortar Required 229
Timber Bridges and Structures, Specifications 238, 239
Timber Piles 238
Timber, Preservative Treatment of.... 239
Traffic Bound Gravel or Crushed Stone Surface Course, Specifications..... 188
Traffic Stripping Cost $40 Per Mile.. 242
Traffic Test for Low-Cost Roads..... 229
Traffic Volume, Relation to Degree of Improvement 212
Traffic Zone Paint Specifications..... 241
Trap Rock, Weight of..... 216
Trees, Care in California..... 186

V

Vitrified Pipe, Table of Weights Per Foot and Mortar Required..... 229

W

Water Required for Concrete Paving. 233
Water Supply in Road Construction 231, 233
Waterbound Macadam Base Course, Specifications 192
Waterbound Macadam Base and Surface Courses, Specifications for Crushed Stone and Screenings..... 193
Waterbound Macadam, Quantities for Estimating Purposes 194
Waterbound Macadam, Spread of Stone 194
Waterbound Macadam Surface Course, Specifications 193
Weather Conditions and Working Days 229, 230
Wire Guard Fabric, Specifications... 237
Wood Guard Rail, Specifications.... 235
Wood Preserving 239
Working Days and Weather Conditions 229, 230

CLASSIFIED DIRECTORY OF MANUFACTURERS

An index of the products of the leading manufacturers of machinery, equipment and materials used in the construction, maintenance and operation of Highways and Streets.

Products, as a rule, are indexed under the chief noun, but cross references are also given to facilitate finding any article desired. In some cases, space users in this issue are given listings of products which they do not illustrate or describe in connection with the products shown; an inquiry, however, will have prompt response.

For convenience in making inquiries of firms listed, mailing cards will be found in the classified directory section, page 139.

ACCELERATORS FOR CONCRETE
- Calcium Chloride Association (for list of members see Calcium Chloride).

ADMIXTURES FOR CONCRETE
- Johns-Manville, 22 E. 40th St., New York, N. Y.

AERIAL SURVEYS
- Abrams Aerial Survey Corporation, Lansing, Mich.

AFTERCOOLERS, AIR
- Sullivan Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

ASBESTOS-CEMENT CULVERT PIPE
- Johns-Manville, 22 E. 40th St., New York, N. Y.

ASPHALT
- Johns-Manville Sales Corp., 22 E. 40th St., New York, N. Y.
- The Texas Company, 135 E. 42nd St., New York, N. Y.
- The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
- Skelly Oil Company, 2534 Madison, Kansas City, Mo.
- Mexican Petroleum Corp., 122 E. 42nd St., New York, N. Y.
- The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
- Servicised Products Corp., 6051 W. 65th St., Chicago.
- Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
- Standard Oil Co. of New York, 26 Broadway, New York, N. Y.
- Macasphalt Corporation, 34-03 Lawrence St., Flushing, N. Y.

ASPHALT BLOCKS, PAVING
- Mexican Petroleum Corp., 122 E. 42nd St., New York, N. Y.

ASPHALT BRICK FILLER
- Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.

ASPHALT EMULSION
- Johns-Manville Sales Corp., 22 E. 40th St., New York, N. Y.
- The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
- Macasphalt Corporation, 34-03 Lawrence St., Flushing, N. Y.
- The Texas Company, 135 E. 42nd St., New York, N. Y.
- Mexican Petroleum Corp., 122 E. 42nd St., New York, N. Y.
- The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
- Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

ASPHALT FILLERS
- Johns-Manville Sales Corp., 22 E. 40th St., New York, N. Y.
- Skelly Oil Company, 2534 Madison, Kansas City, Mo.
- The Texas Company, 135 E. 42nd St., New York, N. Y.
- The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
- The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
- Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
- Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

ASPHALT HEATING KETTLES
- Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.
- The Jos. Honhorst Company, 1016 W. Sixth St., Cincinnati, O.
- Good Roads Machinery Corp., Kennett Square, Pa.

ASPHALT HEATERS
- Cleaver-Brooks Company, 2784 N. 32nd St., Milwaukee, Wis.
- The Jos. Honhorst Co., 1016 W. Sixth St., Cincinnati, O.

ASPHALT JOINTS
- Johns-Manville Sales Corp., 22 E. 40th St., New York, N. Y.
- The Texas Company, 135 E. 42nd St., New York, N. Y.
- Mexican Petroleum Corp., 122 E. 42nd St., New York, N. Y.
- The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
- The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
- Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
- Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.

ASPHALT PAVEMENT REPAIR OUTFITS
- Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.
- Tarrant Mfg. Co., 12 Maple Ave., Saratoga Springs, N. Y.

ASPHALT PLANKING
- Johns-Manville Sales Corp., 22 E. 40th St., New York, N. Y.
- The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
- Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.

ASPHALT PLANTS, PORTABLE
- White Mfg. Co., 1227 W. Beardsley Ave., Elkhart, Ind.
- Blaw-Knox Company, Pittsburgh, Pa.

ASPHALT, ROOF COATING
- Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.

Johns-Manville, 22 E. 40th St., New York, N. Y.
The Texas Company, 135 E. 42nd St., New York, N. Y.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, O.
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.

ASPHALT SPREADERS
Blaw-Knox Company, Pittsburgh, Pa.
The Burch Corporation, Crestline, O.
Flexible Road Joint Machine Co., Warren, O.

ASPHALT TOOL HEATERS
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

ASPHALTIC BRICK FILLER
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
Skelly Oil Company, 2534 Madison, Kansas City, Mo.
The Texas Company, 135 E. 42nd St., New York, N. Y.
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

ASPHALTIC CEMENT
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

ASSOCIATIONS
National Paving Brick Manufacturers' Assn., Washington, D. C.
Portland Cement Assn., Chicago, Ill.
Toncan Culvert Manufacturers' Assn., Youngstown, O.

AUGERS, POSTHOLE
Cleveland Tractor, Cleveland, Ohio.

AUTOMOBILE AND TRUCK WASHERS
Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis, Mo.

BACKFILLERS
Cleveland Tractor, Cleveland, Ohio.
The Parsons Company, Newton, Iowa.
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Continental Roll & Steel Foundry Co., Industrial Equip. Div., 332 S. Michigan Ave., Chicago, Ill.
Bucyrus-Erie Company, South Milwaukee, Wis.

BACK SLOPERS
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Blaw-Knox Company, Pittsburgh, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.
J. D. Adams Co., 217 S. Belmont Ave., Indianapolis, Ind.

BAR BENDERS
C. H. & E. Mfg. Co., Inc., 120 E. Mineral St., Milwaukee, Wis.

BAR CUTTERS
C. H. & E. Mfg. Co., Inc., 120 E. Mineral St., Milwaukee, Wis.

BARS, IRON AND STEEL
Tuthill Spring Co., 760 Polk St., Chicago, Ill.
Truscon Steel Company, Youngstown, O.

BAR CHAINS, REINFORCING
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.

BAR SUPPORTS
Highway Steel Products Co., 1324 McKinley St., Chicago Heights, Ill.

BAR TIES
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.

BARRICADES, FOLDING STEEL
The Toledo Pressed Steel Co., 397 Phillips Ave., Toledo, Ohio.

BATCH BOXES
The Burch Corporation, Crestline, Ohio.
Blaw-Knox Company, Pittsburgh, Pa.

BARS, CONCRETE REINFORCING
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.
Truscon Steel Company, Youngstown, O.

BARS, IRON AND STEEL
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.

BEARINGS, BALL
Marlin-Rockwell Corp., 402 Chandler St., Jamestown, N. Y.
Norma-Hoffmann Bearings Corp., Stamford, Conn.

BEARINGS, ROLLER
Norma-Hoffmann Bearings Corp., Stamford, Conn.
The Timken Roller Bearing Co., Canton, O.

BEARINGS, THRUST, BALL
Norma-Hoffmann Bearings Corp., Stamford, Conn.

BELT CONVEYORS
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
Universal Crusher Co., 641 "C" Ave. West, Cedar Rapids, Iowa.
Day Pulverizer Company, Knoxville, Tenn.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
The Burch Corporation, Crestline, Ohio.
Norma-Hoffmann Bearings Corp., Stamford, Conn.

BINS, STORAGE
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
Universal Crusher Co., 641 "C" Ave. West, Cedar Rapids, Iowa.
Blaw-Knox Company, Pittsburgh, Pa.
Industrial Brownhoist Corporation, Bay City, Mich.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
The Burch Corporation, Crestline, Ohio.
Good Roads Machinery Corp., Kennett Square, Pa.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Heltzel Steel Form & Iron Co., Warren, O.

BITS (DETACHABLE "JACKBITS") AND DRILL RODS
Ingersoll-Rand Company, 11 Broadway, New York, N. Y.

BITUMINOUS HEATERS AND BOOSTERS
Cleaver-Brooks Co., 2784 N. 32nd St., Milwaukee, Wis.

BITUMINOUS PAVERS AND FINISHERS
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
Flexible Road Joint Machine Co., Warren, O.
The Galion Iron Works & Mfg. Co., Galion, O.
W. A. Riddell Company, Bucyrus, O.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

BLADE GRADERS
The Firman L. Carswell Mfg. Co., Valley and McAlpine Sts., Kansas City, Kan.
The Galion Iron Works & Mfg. Co., Galion, O.
J. D. Adams Co., 217 S. Belmont Ave., Indianapolis, Ind.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

BLADES, SCRAPER AND GRADER
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Anderson Engineering Co., Statler Bldg., Boston, Mass.
The Galion Iron Works & Mfg. Co., Galion, O.
J. D. Adams Co., 217 S. Belmont Ave., Indianapolis, Ind.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

BLASTING ACCESSORIES
Hercules Powder Company, Wilmington, Del.

BLASTING POWDER
(See Explosives.)

BLOCKS AND TACKLE
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.

BLOW TORCHES
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

BOILERS, OIL BURNING
Cleaver-Brooks Co., 2784 N. 32nd St., Milwaukee, Wis.

BORDER ASPHALT
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

BREAKERS, CONCRETE
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Ingersoll-Rand Company, 11 Broadway, New York.

BRICK, PAVING
National Paving Brick Association, National Press Bldg., Washington, D. C. (For list of members, see Pavement, Brick Manufacturers.)

BRIDGE PAINTS
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Truscon Laboratories, Detroit, Mich.

BRIDGE PLANKING OR FLOORING
Johns-Manville Sales Corp., 22 E. 40th St., New York, N. Y.
Southern Wood Preserving Co., Atlanta, Ga.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, O.
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.

BUCKETS, CABLEWAY, EXCAVATOR
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Sauerman Bros., 438 S. Clinton St., Chicago, Ill.

BUCKETS, CLAMSHELL
Blaw-Knox Company, Pittsburgh, Pa.
Industrial Brownhoist Corporation, Bay City, Mich.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

BUCKETS, CONCRETE
Blaw-Knox Company, Pittsburgh, Pa.

BUCKETS, DRAGLINE, EXCAVATOR
Blaw-Knox Company, Pittsburgh, Pa.
Bucyrus-Erie Company, South Milwaukee, Wis.
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.

BUCKETS, DRAGLINE SCRAPER
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Sauerman Bros., 438 S. Clinton St., Chicago, Ill.

BUCKET ELEVATORS
Universal Crusher Co., 641 "C" Ave. West, Cedar Rapids, Iowa.
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
Day Pulverizer Company, Knoxville, Tenn.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Blaw-Knox Company, Pittsburgh, Pa.
Good Roads Machinery Corp., Kennett Square, Pa.

BUCKETS, ELEVATOR AND CONVEYOR
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

BUILDINGS, PORTABLE, STEEL
Blaw-Knox Company, Pittsburgh, Pa.
Truscon Steel Company, Youngstown, O.

BULLDOZERS
Cleveland Tractor, Cleveland, Ohio.
Blaw-Knox Company, Pittsburgh, Pa.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
The Frank G. Hough Company, 919 N. Michigan Ave., Chicago, Ill.
Continental Roll & Steel Foundry Co., Industrial Eqpt. Div., 332 S. Michigan Ave., Chicago, Ill.
J. D. Adams Co., 217 S. Belmont Ave., Indianapolis, Ind.

BURNERS FOR MELTING KETTLES
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

BURNERS FOR ROAD OIL DISTRIBUTORS
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

CABLE, HIGHWAY GUARD
American Steel & Wire Co., 208 S. La Salle St., Chicago, Ill.
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.
Page Steel & Wire Division, American Chain Company, Inc., Monessen, Pa.

CABLE FITTINGS
American Steel & Wire Co., 208 S. La Salle St., Chicago, Ill.
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.
Page Steel & Wire Division, American Chain Company, Inc., Monessen, Pa.

CABLE INSULATION
Mexican Petroleum Corp., 122 E. 42nd St., New York.

CABLEWAYS
Sauerman Bros., 438 S. Clinton St., Chicago, Ill.
American Steel & Wire Co., 208 S. La Salle St., Chicago, Ill.

CALCIUM CARBIDE
National Carbide Sales Corp., Lincoln Bldg., 60 E. 42nd St., New York.

CALCIUM CHLORIDE
The Grasselli Chemical Co., Inc., 629 Euclid Ave., Cleveland, Ohio.
Calcium Chloride Association—
Columbia Alkali Corp., Barberton, O.
Dow Chemical Co., Midland, Mich.
Michigan Alkali Co., 10 E. 40th St., New York City.
Solvay Sales Corp., 61 Broadway, New York City.

CANS, GARBAGE AND STREET REFUSE
Tarrant Mfg. Co., 12 Maple Ave., Saratoga Springs, N. Y.

CAPS, ELECTRIC BLASTING, ALL METAL DELAY
Hercules Powder Company, Wilmington, Del.

CAR MOVERS
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

CARPETING ASPHALTS
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

CARS, SKIP
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

CARTS, DUMP
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

CARTS, STREET CLEANERS'
Tarrant Mfg. Co., 12 Maple Ave., Saratoga Springs, N. Y.

CASTINGS, IRON AND STEEL
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Truscon Steel Company, Pressed Steel Division, Cleveland, O.

CASTINGS, ROAD AND STREET
The Burch Corporation, Crestline, Ohio.
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.

CATCH BASINS
The Burch Corporation, Crestline, Ohio.

CEMENT GUNS
The Gunitor Company, 1227 W. Beardsley Ave., Elkhart, Ind.

CEMENT HANDLING EQUIPMENT
Blaw-Knox Company, Pittsburgh, Pa.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Heltzel Steel Form & Iron Co., Warren, O.

CENTRAL MIXING PLANTS
Blaw-Knox Company, Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.

CHAINS
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

CHAINS, STEEL AND MALLEABLE SPROCKET
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

CLAMPS, WIRE ROPE
American Steel & Wire Co., 208 S. La Salle St., Chicago.
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.

CLAMPS, CABLE, HIGHWAY GUARD
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.
Page Steel and Wire Division, American Chain Co., Inc., Monessen, Pa.

CLIPPERS, BOLT
H. K. Porter, Inc., Everett, Mass.

CLUTCHES
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

COAL AND ORE CONVEYING AND LOADING MACHINERY
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

COLD PATCHING ASPHALT
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

COLD PATCH, BITUMINOUS
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
The Texas Company, 135 E. 42nd St., New York, N. Y.
Mexican Petroleum Corp., 122 E. 42nd St., New York.
The Barrett Company, 40 Rector St., New York.

COMPRESSORS, PORTABLE
Cleveland Tractor, Cleveland, Ohio.
Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis, Mo.
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.
Ingersoll-Rand Company, 11 Broadway, New York.

COMPRESSORS, STATIONARY
Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis, Mo.
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.
Ingersoll-Rand Company, 11 Broadway, New York.

CONCRETE ADMIXTURES
Johns-Manville, 22 E. 40th St., New York, N. Y.

CONCRETE, ASPHALTS
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
The Texas Company, 135 E. 42nd St., New York, N. Y.

CONCRETE CURING
The Texas Company, 135 E. 42nd St., New York, N. Y.
Philadelphia Quartz Co., 127 S. Third St., Philadelphia, Pa.
The Grasselli Chemical Co., Inc., 629 Euclid Ave., Cleveland, Ohio.
The Barrett Company, 40 Rector St., New York.
Calcium Chloride Association (for list of members, see CALCIUM CHLORIDE).

CONCRETE CURING MACHINES
Tarrant Mfg. Co., 12 Maple Ave., Saratoga Springs, N. Y.
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

CONCRETE HARDENING
The Grasselli Chemical Co., Inc., 629 Euclid Ave., Cleveland, Ohio.

CONCRETE MIXING PLANTS—COMMERCIAL
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.
Heltzel Steel Form & Iron Co., Warren, O.

CONCRETE REINFORCEMENT
Highway Steel Products Co., 1324 McKinley St., Chicago Heights, Ill.
American Steel & Wire Co., 208 S. La Salle St., Chicago.
Truscon Steel Company, Youngstown, O.
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.

CONCRETE SURFACE INSPECTOR
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

CONCRETE, TAR
The Barrett Company, 40 Rector St., New York.

CONDUITS, UNDERGROUND
Southern Wood Preserving Co., Atlanta, Ga.

CONTRACTION JOINTS
Highway Steel Products Co., 1324 McKinley St., Chicago Heights, Ill.
Flexible Road Joint Machine Co., Warren, O.
Truscon Steel Company, Youngstown, O.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, O.

CONVEYORS, BELT
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
Day Pulverizer Company, Knoxville, Tenn.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
The Burch Corporation, Crestline, Ohio.
Blaw-Knox Company, Pittsburgh, Pa.
Good Roads Machinery Corp., Kennett Square, Pa.

CONVEYORS, BELT AND BUCKET
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

CONVEYORS, BUCKET
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
Day Pulverizer Company, Knoxville, Tenn.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Good Roads Machinery Corp., Kennett Square, Pa.

CONVEYORS, CHAIN
Day Pulverizer Company, Knoxville, Tenn.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

CONVEYORS, PORTABLE BELT
Blaw-Knox Company, Pittsburgh, Pa.
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
The Burch Corporation, Crestline, O.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

CORRUGATED METAL CULVERTS
The Firman L. Carswell Mfg. Co., Valley and McAlpine Sts., Kansas City, Kan.
The Galion Iron Works & Mfg. Co., Galion, O.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

COUPLINGS, HOSE
Chicago Tubing and Braiding Co., Maywood, Ill.
United Metal Hose Co., Inc., 699 Garrison Ave., New York, N. Y.

CRACK FILLERS, ASPHALT
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
The Burch Corporation, Crestline, O.
The Texas Company, 135 E. 42nd St., New York, N. Y.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, O.
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.

CRACK FILLERS, TAR
The Barrett Company, 40 Rector St., New York.

CRANES, CLAMSHELL
Industrial Brownhoist Corporation, Bay City, Mich.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Bucyrus-Erie Company, South Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

CRANES, CONVERTIBLE, SHOVEL, DRAGLINE, DIESEL
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Bucyrus-Erie Company, South Milwaukee, Wis.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

CRANES, CONVERTIBLE, SHOVEL, DRAGLINE, ELECTRIC
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Link-Belt Company, 910 S. Michigan Ave., Chicago, Ill.
Bucyrus-Erie Company, South Milwaukee, Wis.

CRANES, GASOLINE (Convertible Shovel, Dragline, Etc.)
Industrial Brownhoist Corporation, Bay City, Mich.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Bucyrus-Erie Company, South Milwaukee, Wis.

CRANES, STEAM (Convertible Shovel, Dragline, Etc.)
Industrial Brownhoist Corporation, Bay City, Mich.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Bucyrus-Erie Company, South Milwaukee, Wis.

CRANES, CRAWLER TRACTION
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Bucyrus-Erie Company, South Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

CRANES, GANTRY
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

CRANES, LOCOMOTIVE
Industrial Brownhoist Corporation, Bay City, Mich.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

CRANES, MOTOR TRUCK
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.

CRANES, OVERHEAD TRAVELING
Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis, Mo.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.

CRANES, ROAD
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

CRANES, TRACTOR
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
Bucyrus-Erie Company, South Milwaukee, Wis.

CRANES, WRECKING, RAILWAY, STEAM
Industrial Brownhoist Corp., Bay City, Mich.

CRAWLERS
Cleveland Tractor, Cleveland, Ohio.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

CREOSOTE
The Barrett Company, 40 Rector St., New York.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.

CREOSOTED TIMBER, PILING, ETC.
Southern Wood Preserving Co., Atlanta, Ga.

CREOSOTED WOOD BLOCKS, PAVING
Southern Wood Preserving Co., Atlanta, Ga.

CRUSHERS, PORTABLE, WITH ELEVATORS AND SCREENS
Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.
Day Pulverizer Company, Knoxville, Tenn.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Good Roads Machinery Corp., Kennett Square, Pa.

CRUSHERS, PULVERIZERS
Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.
Day Pulverizer Company, Knoxville, Tenn.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

CRUSHERS, ROCK JAW
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Blaw-Knox Company, Pittsburgh, Pa.

CRUSHERS, ROCK, PORTABLE
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.
Day Pulverizer Company, Knoxville, Tenn.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
Good Roads Machinery Corp., Kennett Square, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.

CRUSHERS, ROCK, STATIONARY
Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.
Day Pulverizer Company, Knoxville, Tenn.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Good Roads Machinery Corp., Kennett Square, Pa.

CRUSHERS, TRAVELING
Day Pulverizer Company, Knoxville, Tenn.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Ia.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

CRUSHING AND SCREENING PLANTS
Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.
Day Pulverizer Company, Knoxville, Tenn.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Blaw-Knox Company, Pittsburgh, Pa.
Good Roads Machinery Corp., Kennett Square, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.

CULVERT COATING ASPHALTS
Mexican Petroleum Corp., 122 E. 42nd St., New York.

CULVERTS, ASBESTOS-CEMENT
Johns-Manville, 22 E. 40th St., New York, N. Y.

CULVERTS, CAST IRON
The Burch Corporation, Crestline, Ohio.
The Galion Iron Works & Mfg. Co., Galion, O.
United States Pipe & Foundry Co., Burling, N. J.

CULVERTS, CORRUGATED IRON
Blaw-Knox Company, Pittsburgh, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.
Toncan Culvert Manufacturers' Association—
Beall Pipe & Tank Corp., Portland, Ore.
Berger Metal Culvert Co. of N. E., 307 Dorchester Ave., Boston, Mass.
Canton Culvert Co., Canton, Ohio.
Firman L. Carswell Mfg. Co., Kansas City, Kan.
Dominion Metal & Culvert Corp., Roanoke, Va.
A. N. Eaton Metal Products Co. of Montana, Billings, Mont.
A. N. Eaton Metal Products Co., Omaha, Nebr.
Eastern Culvert Corp., 16th St. & Washington Ave., Philadelphia, Pa.
Empire State Culvert Corp., Groton, N. Y.
H. V. Johnston Culvert Co., Minneapolis, Minn.
Jensen Bridge & Supply Co., Sandusky, Mich.
Wm. E. Newman & Sons Co., Ogden, Utah.
Thompson Mfg. Co., 30th & Larimer Sts., Denver, Colo.
Tri-State Culvert Mfg. Co., Memphis, Tenn.
Tri-State Culvert Mfg. Co., Atlanta, Ga.
Wyatt Metal & Boiler Works, Dallas, Texas.
Western Pipe & Steel Co., 444 Market St., San Francisco, Calif.
Western Pipe & Steel Co., 5717 Santa Fe Ave., Los Angeles, Calif.
Bluegrass Pipe & Culvert Co., 17th & Arbegust Sts., Louisville, Ky.

CULVERTS, CORRUGATED METAL
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
The Galion Iron Works & Mfg. Co., Galion, O.
Toncan Culvert Manufacturers' Association (for list of members, see CULVERTS, CORRUGATED IRON).

CULVERTS, SECTIONAL CLAY PIPE
Toncan Culvert Manufacturers' Association (for list of members, see CULVERTS, CORRUGATED IRON).

CULVERTS, SECTIONAL PLATE ARCHES
Toncan Culvert Manufacturers' Association (for list of members, see CULVERTS, CORRUGATED IRON).

CUTBACK ASPHALT
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

CUTTERS. BOLT
H. K. Porter, Inc., Everett, Mass.

CUTTERS, ROD
H. K. Porter, Inc., Everett, Mass.

DIGGERS, CLAY
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.
Ingersoll-Rand Company, 11 Broadway, New York.

DIGGERS, POSTHOLE
Cleveland Tractor, Cleveland, Ohio.

DIPPERS, ASPHALT
Tarrant Mfg. Co., 12 Maple Ave., Saratoga Springs, N. Y.

DISTRIBUTORS, CALCIUM CHLORIDE
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.
The Grasselli Chemical Co., Inc., 629 Euclid Ave., Cleveland, Ohio.
Calcium Chloride Association (for list of members, see CALCIUM CHLORIDE).

DISTRIBUTORS, OIL, TAR AND ASPHALT
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Good Roads Machinery Corp., Kennett Square, Pa.
E. D. Etnyre & Co., Oregon, Ill.

DOWEL SOCKETS
Highway Steel Products Company, 1324 McKinley St., Chicago Heights, Ill.

DRAGLINE EXCAVATOR
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
Bucyrus-Erie Company, South Milwaukee, Wis.

DRAGS, ROAD
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
The Burch Corporation, Crestline, Ohio.
Blaw-Knox Company, Pittsburgh, Pa.
Good Roads Machinery Corp., Kennett Square, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.

DREDGES
Bucyrus-Erie Company, South Milwaukee, Wis.

DRILL MOUNTINGS AND ACCESSORIES
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.
Ingersoll-Rand Company, 11 Broadway, New York.

DRILL SHARPENING MACHINES
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.
Ingersoll-Rand Company, 11 Broadway, New York.

DRILL STEEL
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.
Ingersoll-Rand Company, 11 Broadway, New York.

DRILLING TOOLS AND SUPPLIES
Bucyrus-Erie Company, South Milwaukee, Wis.

DRILLS, BLAST HOLE
Bucyrus-Erie Company, South Milwaukee, Wis.

DRILLS, ROCK, PNEUMATIC
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.
Ingersoll-Rand Company, 11 Broadway, New York.

DRILLS, ROCK, WAGON MOUNTED
Ingersoll-Rand Company, 11 Broadway, New York, N. Y.

DYNAMITE
(See EXPLOSIVES.)

DRYERS, SAND AND GRAVEL
White Mfg. Co., 1227 W. Beardsley Ave., Elkhart, Ind.

DUST CONTROL
Blaw-Knox Company, Pittsburgh, Pa.
The Texas Company, 135 E. 42nd St., New York, N. Y.
Calcium Chloride Association (for list of members, see CALCIUM CHLORIDE).
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.

ELEVATORS, BUCKET
Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

ELEVATORS, CONTRACTORS' MATERIAL
Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Blaw-Knox Company, Pittsburgh, Pa.

ELEVATORS AND CONVEYORS
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

EMULSIONS, ASPHALT
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
Johns-Manville Sales Corp., 22 E. 40th St., New York.
The Texas Company, 135 E. 42nd St., New York, N. Y.
Mexican Petroleum Corp., 122 E. 42nd St., New York.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

ENGINEERS, AERIAL SURVEY
The Abrams Aerial Survey Corp., Lansing, Mich.

ENGINES, DIESEL
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.
Hercules Motors Corporation, Canton, Ohio.
Ingersoll-Rand Company, 11 Broadway, New York.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.

ENGINES, GASOLINE
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.
Hercules Motors Corporation, Canton, Ohio.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

ENGINES, KEROSENE
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.
Hercules Motors Corporation, Canton, Ohio.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

ENGINES, NATURAL GAS
Hercules Motors Corporation, Canton, Ohio.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

ENGINES OIL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.
Ingersoll-Rand Company, 11 Broadway, New York, N. Y.
International Harvester Co. of America, 606 S. Michigan Ave., Chicago.

ENGINES, INTERNAL COMBUSTION
Hercules Motors Corporation, Canton, Ohio.
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill.

EQUIPMENT, MATERIAL HANDLING
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Heltzel Steel Form & Iron Co., Warren, O.

EXCAVATORS, BUCKET
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

EXCAVATORS, CRANE
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Bucyrus-Erie Company, South Milwaukee, Wis.

EXCAVATORS, DITCH AND TRENCH
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
C. H. & E. Mfg. Co., Inc., 120 E. Mineral St., Milwaukee, Wis.

EXCAVATORS, DITCH, TRENCH AND SEWER
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Bucyrus-Erie Company, South Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

EXCAVATORS, DRAGLINE
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Bucyrus-Erie Company, South Milwaukee, Wis.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

EXCAVATORS, POWER
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Bucyrus-Erie Company, South Milwaukee, Wis.
Sauerman Bros., 438 S. Clinton St., Chicago, Ill.
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.

EXCAVATORS, SEWER AND TRENCH
The Parsons Company, Newton, Iowa.

EXCAVATORS, SLACKLINE, CABLEWAY
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Sauerman Bros., 438 S. Clinton St., Chicago, Ill.

EXPANDED METAL
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.
Truscon Steel Company, Youngstown, O.

EXPANSION JOINTS
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
Highway Steel Products Company, 1324 McKinley St., Chicago Heights, Ill.
Johns-Manville Sales Corp., 22 E. 40th St., New York.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
C. H. & E. Mfg. Co., Inc., 120 E. Mineral St., Milwaukee, Wis.
Flexible Road Joint Machine Co., Warren, O.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
Truscon Steel Company, Youngstown, O.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.
Wepsco Steel Products Co., Blue Island, Ill.

EXPANSION JOINT FILLERS
Johns-Manville Sales Corp., 22 E. 40th St., New York.
The Texas Company, 135 E. 42nd St., New York.
The Barrett Company, 40 Rector St., New York.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

EXPANSION JOINTS, METAL
Highway Steel Products Company, 1324 McKinley St., Chicago Heights, Ill.
Wepsco Steel Products Co., Blue Island, Ill.
Heltzel Steel Form & Iron Co., Warren, O.
Truscon Steel Company, Youngstown, O.
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.

EXPLOSIVES
Hercules Powder Co., Wilmington, Del.

FENCE, HIGHWAY
American Steel & Wire Co., 208 S. La Salle St., Chicago.
Page Steel and Wire Division, American Chain Co., Inc., Monessen, Pa.
Truscon Steel Company, Youngstown, O.
Tuthill Spring Company, 760 Polk St., Chicago, Ill.

FENCE POSTS
American Steel & Wire Co., 208 S. La Salle St., Chicago.
Southern Wood Preserving Co., Atlanta, Ga.

FILLERS, ASPHALT
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
The Texas Company, 135 E. 42nd St., New York.
Mexican Petroleum Corp., 122 E. 42nd St., New York.
The Burch Corporation, Crestline, Ohio.
Johns-Manville Sales Corp., 22 E. 40th St., New York.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
Skelly Oil Co., 2534 Madison, Kansas City, Mo.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

FILLERS, TAR
The Burch Corporation, Crestline, Ohio.
The Barrett Company, 40 Rector St., New York.

FILLING MACHINES, JOINT AND CRACK
Tarrant Mfg. Co., 12 Maple Ave., Saratoga Springs, N. Y.
The Burch Corporation, Crestline, Ohio.

FINISHERS, CONCRETE ROAD
Blaw-Knox Company, Pittsburgh, Pa.
Flexible Road Joint Machine Co., Warren, O.

FLOOD LIGHTS
National Carbide Sales Corp., Lincoln Bldg., 60 E. 42nd St., New York.
Truscon Steel Co., Youngstown, O.

FLOORING, BRIDGE
Johns-Manville Sales Corp., 22 E. 40th St., New York.
Blaw-Knox Company, Pittsburgh, Pa.
Southern Wood Preserving Co., Atlanta, Ga.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
Truscon Steel Co., Youngstown, O.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, O.

FLOORING (Non-skid)
Blaw-Knox Company, Pittsburgh, Pa.
The Texas Company, 135 E. 42nd St., New York.
Johns-Manville Sales Corp., 22 E. 40th St., New York.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
Truscon Steel Co., Youngstown, O.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, O.

FLUSHERS, STREET
E. D. Etnyre & Co., Oregon, Ill.

FORGES, COKE AND OIL, DRILL STEEL
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

FORM OIL, ASPHALT
Skelly Oil Company, 2534 Madison, Kansas City, Mo.

FORMS, CONCRETE, HIGHWAY
Blaw-Knox Company, Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.
Metal Forms Corp., 3304 N. Booth St., Milwaukee, Wis.
Truscon Steel Co., Youngstown, O.
Highway Steel Products Company, 1324 McKinley St., Chicago, Heights, Ill.

FORM CLAMPS
Highway Steel Products Company, 1324 McKinley St., Chicago Heights, Ill.

FORM OIL, ASPHALT
Skelly Oil Company, 2534 Madison, Kansas City, Mo.
The Texas Company, 135 E. 42nd St., New York, N. Y.
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.

FORMS, CONCRETE MANHOLE
Metal Forms Corp., 3304 N. Booth St., Milwaukee, Wis.
Heltzel Steel Form & Iron Co., Warren, O.

FORMS, CULVERT, COLLAPSIBLE
Metal Forms Corp., 3304 N. Booth St., Milwaukee, Wis.
Heltzel Steel Form & Iron Co., Warren, O.

FORMS, CURB AND GUTTER
Blaw-Knox Company, Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.
Metal Forms Corp., 3304 N. Booth St., Milwaukee, Wis.
Truscon Steel Co., Youngstown, O.

FORMS, SEWER AND TUNNEL
Blaw-Knox Company, Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.
Metal Forms Corp., 3304 N. Booth St., Milwaukee, Wis.

FORMS, SIDEWALK
Blaw-Knox Company, Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.
Metal Forms Corp., 3304 N. Booth St., Milwaukee, Wis.
Truscon Steel Co., Youngstown, O.

FORMS, UNIVERSAL
Blaw-Knox Company, Pittsburgh, Pa.
Metal Forms Corp., 3304 N. Booth St., Milwaukee, Wis.
Heltzel Steel Form & Iron Co., Warren, O.

FORMS, WALLS AND BUILDINGS
Metal Forms Corp., 3304 N. Booth St., Milwaukee, Wis.
Heltzel Steel Form & Iron Co., Warren, O.

FUEL OILS
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.

FURNACES, DRILL STEEL
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.

FURNACES, LEAD MELTING
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

GARAGE AIR COMPRESSORS
Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis Mo.

GATES, BIN
Blaw-Knox Company, Pittsburgh, Pa.
Good Roads Machinery Corp., Kennett Square, Pa.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Heltzel Steel Form & Iron Co., Warren, O.

GATES, CONCRETE HOPPER
Blaw-Knox Company, Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.

GEARS
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

GENERATORS AND MOTORS, ELECTRIC
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Fairbanks, Morse & Co., 900 S. Wabash, Chicago, Ill.

GLUTRIN ROAD BINDERS, LIQUID
Robeson Process Co., 230 Park Ave., New York.

GRADE RIPPER
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Continental Roll & Steel Foundry Co., Industrial Eqpt. Div., 332 S. Michigan Ave., Chicago, Ill.
Galion Iron Works & Mfg. Co., Galion, O.
J. D. Adams Co., 217 S. Belmont Ave., Indianapolis, Ind.

GRADERS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Blaw-Knox Co., Pittsburgh, Pa.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
W. A. Riddell Company, Bucyrus, O.

GRADER BLADES
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
Blaw-Knox Company, Pittsburgh, Pa.
Good Roads Machinery Corp., Kennett Square, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.

GRADERS, ELEVATING
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

GRADERS, HORSE-DRAWN
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Good Roads Machinery Corp., Kennett Square, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

GRADERS, POWER AND HORSE-DRAWN
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
The Galion Iron Works & Mfg. Co., Galion, O.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

GRADERS, LEANING WHEEL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
Blaw-Knox Company, Pittsburgh, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.
W. A. Riddell Company, Bucyrus, O.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

GRADERS, MOTOR PATROL
Cleveland Tractor, Cleveland, Ohio.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
The Huber Manufacturing Co., Marion, Ohio.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
The Galion Iron Works & Mfg. Co., Galion, O.
W. A. Riddell Company, Bucyrus, O.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

GRADERS, ROAD
Blaw-Knox Company, Pittsburgh, Pa.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
The Galion Iron Works & Mfg. Co., Galion, O.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
Heltzel Steel Form & Iron Co., Warren, O.
The Firman L. Carswell Mfg. Co., Valley and McAlpine Sts., Kansas City, Mo.
W. A. Riddell Company, Bucyrus, O.

GRADERS, STRAIGHT WHEEL
Blaw-Knox Company, Pittsburgh, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

GRADERS, ROAD, MOTOR CONTROLLED
Blaw-Knox Company, Pittsburgh, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.
W. A. Riddell Company, Bucyrus, O.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

GRADERS, ROAD, POWER
Blaw-Knox Company, Pittsburgh, Pa.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

The Galion Iron Works & Mfg. Co., Galion, O.
W. A. Riddell Company, Bucyrus, O.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
The Huber Manufacturing Co., Marion, O.

GRAPPLES, ROCK
Blaw-Knox Company, Pittsburgh, Pa.

GRAPPLES, WOOD
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

GRINDERS, PNEUMATIC, PORTABLE
Ingersoll-Rand Company, 11 Broadway, New York.

GUARD RAIL
Truscon Steel Co., Youngstown, O.
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.
Toncan Culvert Manufacturers' Association (for list of members, see CULVERTS, CORRUGATED IRON).
Tuthill Spring Company, 760 Polk St., Chicago, Ill.
American Steel & Wire Co., 208 S. La Salle St., Chicago, Ill.

GUARDS, HIGHWAY
Tuthill Spring Co., 760 Polk St., Chicago, Ill.
American Steel & Wire Co., 208 S. La Salle St., Chicago.
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.
Southern Wood Preserving Co., Atlanta, Ga.
Page Steel and Wire Division, American Chain Co., Inc., Monessen, Pa.
Truscon Steel Company, Youngstown, O.

GUARD RAIL FITTINGS
American Steel & Wire Co., 208 S. La Salle St., Chicago.
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.
Page Steel and Wire Division, American Chain Co., Inc., Monessen, Pa.

HAMMERS, CAULKING, CHIPPING AND RIVETING
Ingersoll-Rand Company, 11 Broadway, New York.

HEATERS, ASPHALT, PITCH AND TAR
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.
White Mfg. Co., 1227 W. Beardsley Ave., Elkhart, Ind.

HEATERS, CONCRETE
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.
White Mfg. Co., 1227 W. Beardsley Ave., Elkhart, Ind.

HEATERS, KETTLE
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.
The Jos. Honhorst Co., 1016 W. Sixth St., Cincinnati, O.

HEATERS AND PATCHERS, ASPHALT SURFACE
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

HEATERS, ROAD OIL
Cleaver-Brooks Company, 2784 N. 32nd St., Milwaukee, Wis.

HEATERS, TANK CAR
Cleaver-Brooks Company, 2784 N. 32nd St., Milwaukee, Wis.

HEATERS, TOOL, ASPHALT
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

HIGHWAY CROSSING PLANK
Southern Wood Preserving Co., Atlanta, Ga.
Johns-Manville Sales Corp., 22 E. 40th St., New York.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
Truscon Steel Company, Youngstown, O.

HIGHWAY CROSSINGS, ASPHALT
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
Johns-Manville Sales Corp., 22 E. 40th St., New York, N. Y.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, O.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.

HIGHWAY CROSSINGS, ASPHALT PLANK
Johns-Manville Sales Corp., 22 E. 40th St., New York.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.

HIGHWAY CROSSINGS, TAR
The Barrett Company, 40 Rector St., New York.

HIGHWAY MOWERS
(See MOWERS, HIGHWAY.)

HIGHWAY SIGNS AND SIGNALS
Municipal Street Sign Co., Inc., 299 Broadway, New York, N. Y.

HOES, TRENCH
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Bucyrus-Erie Company, South Milwaukee, Wis.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

HOISTS, AIR
Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis, Mo.

HOISTS, AIR MOTOR
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.
Ingersoll-Rand Company, 11 Broadway, New York.

HOISTS, CONTRACTORS'
Ingersoll-Rand Company, 11 Broadway, New York.
C. H. & E. Mfg. Co., Inc., 120 E. Mineral St., Milwaukee, Wis.

HOISTS, DRAGLINE
Sauerman Bros., 438 S. Clinton St., Chicago, Ill.
Link-Belt Company, 300 W. Pershing Road, Chicago, Ill.
C. H. & E. Mfg. Co., Inc., 120 E. Mineral St., Milwaukee, Wis.
Ingersoll-Rand Company, 11 Broadway, New York, N. Y.
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.

HOISTS, SKIP
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

HORSES, FOLDING STEEL
The Toledo Pressed Steel Co., 397 Phillips Ave., Toledo, Ohio.

HOSE, AIR, STEAM, WATER AND OIL
Chicago Tubing & Braiding Co., 216 N. Clinton St., Chicago, Ill.
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.
United Metal Hose Co., Inc., 699 Garrison Ave., New York, N. Y.
Ingersoll-Rand Company, 11 Broadway, New York, N. Y.

HOSE CLAMPS AND COUPLINGS
Chicago Tubing & Braiding Co., 216 N. Clinton St., Chicago, Ill.
Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis Mo.
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.
United Metal Hose Co., Inc., 699 Garrison Ave., New York, N. Y.

HOSE, GASOLINE
Chicago Tubing & Braiding Co., 216 N. Clinton St., Chicago, Ill.
Titeflex Metal Hose Co., 500 Frelinghuysen Ave., Newark, N. J.
United Metal Hose Co., Inc., 699 Garrison Ave., New York, N. Y.

HOSE, METALLIC, FLEXIBLE
- Chicago Tubing & Braiding Co., 216 N. Clinton St., Chicago, Ill.
- Titeflex Metal Hose Co., 500 Frelinghuysen Ave., Newark, N. J.
- United Metal Hose Co., Inc., 699 Garrison Ave., New York, N. Y.

HOSE, OIL
- Chicago Tubing & Braiding Co., 216 N. Clinton St., Chicago, Ill.
- United Metal Hose Co., Inc., 699 Garrison Ave., New York, N. Y.

HOSE, STEAM
- Titeflex Metal Hose Co., 500 Frelinghuysen Ave., Newark, N. J.
- United Metal Hose Co., Inc., 699 Garrison Ave., New York, N. Y.
- Chicago Tubing & Braiding Co., 216 N. Clinton St., Chicago, Ill.

HOSE, TANK, UNLOADING
- Chicago Tubing & Braiding Co., 216 N. Clinton St., Chicago, Ill.
- United Metal Hose Co., Inc., 699 Garrison Ave., New York, N. Y.

HOSE, TAR, ASPHALT, ETC.
- Chicago Tubing & Braiding Co., 216 N. Clinton St., Chicago, Ill.
- United Metal Hose Co., Inc., 699 Garrison Ave., New York, N. Y.

ICE REMOVALS MATERIALS
- The Grasselli Chemical Co., Inc., 629 Euclid Ave., Cleveland, Ohio.
- Calcium Chloride Association (for list of members, see CALCIUM CHLORIDE).

INLETS, CURB
- The Burch Corporation, Crestline, Ohio.

JOINTS, CENTER
- Johns-Manville Sales Corp., 22 E. 40th St., New York.
- The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
- Wepsco Steel Products Co., Blue Island, Ill.
- Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.
- Flexible Road Joint Machine Co., Warren, O.
- Highway Steel Products Co., 1324 McKinley St., Chicago Heights, Ill.
- Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
- Truscon Steel Company, Youngstown, O.
- Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.

JOINTS, EXPANSION PAVING
- The Texas Company, 135 E. 42nd St., New York.
- Mexican Petroleum Corp., 122 E. 42nd St., New York.
- The Barrett Company, 40 Rector St., New York.
- Johns-Manville, 22 E. 40th St., New York.
- The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
- Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.
- Flexible Road Joint Machine Co., Warren, O.
- Highway Steel Products Co., 1324 McKinley St., Chicago Heights, Ill.
- Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
- The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.

JOINT, EXPANSION POURED
- The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
- Skelly Oil Company, 2534 Madison, Kansas City, Mo.
- Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.

JOINT INSTALLERS
- The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
- Flexible Road Joint Machine Co., Warren, O.
- Truscon Steel Company, Youngstown, O.

JOISTS, STEEL
- Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.
- Truscon Steel Company, Youngstown, O.

KEROSENE
- Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
- The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.

KETTLES, ASPHALT, PITCH AND TAR
- Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.
- The Jos. Honhorst Co., 1016 W. Sixth St., Cincinnati, O.

KETTLES FOR ROOFERS, PAVERS, CONTRACTORS
- Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.
- Tarrant Mfg. Co., 12 Maple Ave., Saratoga Springs, N. Y.
- White Mfg. Co., 1227 W. Beardsley Ave., Elkhart, Ind.
- The Jos. Honhorst Co., 1016 W. Sixth St., Cincinnati, O.

LAMPS, CONTRACTORS'
- The Toledo Pressed Steel Co., 397 Phillips Ave., Toledo, Ohio.
- National Carbide Sales Corp., Lincoln Bldg., 60 E. 42nd St., New York, N. Y.

LANTERNS, CONTRACTORS'
- National Carbide Sales Corp., Lincoln Bldg., 60 E. 42nd St., New York, N. Y.

LATH, METAL
- Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.
- Truscon Steel Company, Youngstown, O.

LIFTS, ROTATING, TRUCK TYPE
- Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis, Mo.

LIGHTING PLANTS FOR CONTRACTORS
- Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
- Fairbanks, Morse & Co., 900 S. Wabash, Chicago, Ill.

LIGHTS, CONTRACTORS'
- The Toledo Pressed Steel Co., 397 Phillips Ave., Toledo, Ohio.
- National Carbide Sales Corporation, Lincoln Bldg., 60 E. 42nd St., New York, N. Y.

LINKS, BELT AND WHEEL
- Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

LOADERS, CAR, TRUCK AND WAGON
- Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
- Heltzel Steel Form & Iron Co., Warren, O.

LOADERS
- The Frank G. Hough Company, 919 N. Michigan Ave., Chicago, Ill.
- Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

LOADERS, SAND AND GRAVEL
- Blaw-Knox Company, Pittsburgh, Pa.
- Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

LOADERS, PORTABLE
- Blaw-Knox Company, Pittsburgh, Pa.
- Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
- Heltzel Steel Form & Iron Co., Warren, O.

LOADERS, SNOW
- Zaremba Snow Rooters, 29 E. Market St., Buffalo, N. Y.

LUBRICANTS
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
The Texas Company, 135 E. 42nd St., New York, N. Y.
Skelly Oil Company, 2534 Madison, Kansas City, Mo.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.

MACHINES, ASPHALT SPRAYING
E. D. Etnyre & Co., Oregon, Ill.

MAGNETO, GASOLINE TRACTOR
Scintilla Magneto Co., Inc., Sherman Ave., Sidney, N. Y.
Fairbanks, Morse & Co., 900 S. Wabash, Chicago, Ill.

MAINTAINERS, ROAD
York Modern Corporation, Cor. Mill & Watson St., Unadilla, N. Y.
The Parsons Company, Newton, Iowa.
The Austin-Western Rd. Mchy. Co., 400 N. Michigan Ave., Chicago, Ill.
Root Spring Scraper Company, 527 W. North St., Kalamazoo, Mich.
The Galion Iron Works & Mfg. Co., Galion, O.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
The Burch Corporation, Crestline, Ohio.
Blaw-Knox Company, Pittsburgh, Pa.

MANHOLE COVERS
The Burch Corporation, Crestline, Ohio.

MATERIAL HANDLING EQUIPMENT
Cleveland Tractor, Cleveland, Ohio.
Blaw-Knox Company, Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

MATERIAL WEIGHING MACHINES
Blaw-Knox Company, Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.

METAL DITCH CHECKS
Highway Steel Products Company, 1324 McKinley St., Chicago Heights, Ill.

MESH AND MAT SUPPORTS
Highway Steel Products Company, 1324 McKinley St., Chicago Heights, Ill.
Truscon Steel Company, Youngstown, O.

MIXER AND LEVELER FOR BLACK TOP ROADS
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
The Galion Iron Works & Mfg. Co., Galion, O.
W. A. Riddell Company, Bucyrus, O.

MIXERS, BITUMINOUS
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
Heltzel Steel Form & Iron Co., Warren, O.
W. A. Riddell Co., Bucyrus, O.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

MIXERS, CEMENT AND CONCRETE
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, CHEMICAL (DRY MIXES)
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, CLAY
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, CONCRETE PRODUCTS PLANT
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, FERTILIZER
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, GLASS BATCH
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, GROUT
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, HOT
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, LEAD AND COLOR
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, LOW CHARGING
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, MORTAR
C. H. & E. Mfg. Co., Inc., 120 E. Mineral St., Milwaukee, Wis.

MIXERS, PLASTER
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, PORTABLE TOWER
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, RAILWAY
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS—RETREAD
The Parsons Company, Newton, Iowa.
E. D. Etnyre & Co., Oregon, Ill.
J. D. Adams Co., 217 S. Belmont Ave., Indianapolis, Ind.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

MIXERS, ROAD OR STREET
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

MIXERS, SAND, FOUNDRY
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MIXERS, STEAM JACKETED
The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

MOWERS, HIGHWAY AND RAILWAY
Toro Manufacturing Company, 3042-3210 Snelling Ave., Minneapolis, Minn.
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.

MOWERS, LAWN, POWER
Toro Manufacturing Company, 3042-3210 Snelling Ave., Minneapolis, Minn.

OIL BURNERS
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

OIL BURNERS, PORTABLE HAND PUMP TYPE
Hauck Manufacturing Company, 110-140 Tenth St., Brooklyn, N. Y.
White Manufacturing Company, 1227 W. Beardsley Ave., Elkhart, Ind.

OILERS, ROAD
E. D. Etnyre & Co., Oregon, Ill.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

OILS AND GREASE, LUBRICATING
The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
The Texas Company, 135 E. 42nd St., New York, N. Y.
Skelly Oil Company, 2534 Madison St., Kansas City, Mo.

OILS, ROAD

The Atlantic Refining Co., 260 S. Broad St., Philadelphia Pa.
The Texas Company, 135 E. 42nd St., New York, N. Y.
Skelly Oil Company, 2534 Madison St., Kansas City, Mo.
Mexican Petroleum Corporation, 122 E. 42nd St., New York, N. Y.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

PAINT, ASPHALT

The Atlantic Refining Co., 260 S. Broad St., Philadelphia, Pa.
The Texas Company, 135 E. 42nd St., New York, N. Y.
Skelly Oil Company, 2534 Madison St., Kansas City, Mo.
Mexican Petroleum Corporation, 122 E. 42nd St., New York, N. Y.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Truscon Laboratories, Detroit, Mich.

PAINT, MARKING

The Barrett Company, 40 Rector St., New York, N. Y.

PAINT SPRAY AIR COMPRESSORS

Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis, Mo.

PAINT, WATERPROOFING

Mexican Petroleum Corporation, 122 E. 42nd St., New York, N. Y.
The Barrett Company, 40 Rector St., New York, N. Y.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
The Texas Company, 135 E. 42nd St., New York, N. Y.
Truscon Laboratories, Detroit, Mich.

PAINTS, METAL PROTECTION

The Eagle-Picher Lead Co., Temple Bar Bldg., Cincinnati, O.
The Barrett Company, 40 Rector St., New York, N. Y.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
The Texas Company, 135 E. 42nd St., New York, N. Y.

PAINTS, TAR

The Barrett Company, 40 Rector St., New York, N. Y.

PAINTS, TRAFFIC MARKING

The Barrett Company, 40 Rector St., New York, N. Y
Mexican Petroleum Corp., 122 E. 42nd St., New York, N. Y.

PAPER ASPHALTUM

Mexican Petroleum Corp., 122 E. 42nd St., New York.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.

PATCHERS, ASPHALT SURFACE

Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

PATCHING MATERIAL, ASPHALT

Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.

PATCHING MATERIAL, TAR

The Barrett Company, 40 Rector St., New York.

PAVEMENT, BRICK, MANUFACTURERS

National Paving Brick Association—
Adams Clay Products Co., Indianapolis, Ind.
Albion Brick Co., Albion, Ill.
Alton Brick Co., St. Louis, Mo.
Ava Brick Co., Ava, Ohio.
Cleveland Brick & Clay Co., Cleveland, Ohio.
Crescent Brick Co., Pittsburgh, Pa.
Collinwood Shale Brick & Sup. Co., Cleveland, Ohio.
Danville Brick Co., Danville, Ill.
Decatur Brick Mfg. Co., Decatur, Ill.
Euclid Shale Brick Co., Cleveland, Ohio.
Georgia Vitrified Brick & Clay Co., Augusta, Ga.
Hill Brick Co., East St. Louis, Ill.
Hocking Valley Brick Co., Columbus, Ohio.
Hydraulic-Press Brick Co., St. Louis, Mo.
Martinsville Brick Co., Martinsville, Ind.
F. C. Mayer, Manufacturer, Bridgeville, Pa.
McAvoy Vitrified Brick Co., Philadelphia, Pa.
McLain Fire Brick Co., Wellsville, Ohio.
Medal Brick & Tile Co., Cleveland, Ohio.
Metropolitan Paving Brick Co., Canton, Ohio.
Milliken Brick Co., Wilkinsburg, Pa.
Nelsonville Brick Co., Columbus, Ohio.
Oriental Brick Corp., Crawfordsville, Ind.
Patton Clay Mfg. Co., Patton, Pa.
Peebles Paving Brick Co., Portsmouth, Ohio.
Peoria Brick & Tile Co., Peoria, Ill.
Poston-Herron Brick Co., Attica, Ind.
Poston-Springfield Brick Co., Springfield, Ill.
Purington Paving Brick Co., Galesburg, Ill.
Southern Clay Mfg. Co., Chattanooga, Tenn.
Sterling Brick Co., Olean, N. Y.
Stone Creek Brick Co., Stone Creek, Ohio.
Streator Clay Mfg. Co., Streator, Ill.
Terre Haute Vitrified Brick Works, Terre Haute, Ind.
Toronto Fire Clay Co., Toronto, Ohio.
Veedersburg Paver Co., Veedersburg, Ind.
Western Brick Co., Danville, Ill.
Westport Paving Brick Co., Baltimore, Md.
Zanesville Clay Products Co., Columbus, Ohio.

PAVEMENTS, ASPHALT

The Atlantic Refining Co., 260 S. Broad St., Philadelphia Pa.
The Texas Company, 135 E. 42nd St., New York, N. Y.
Mexican Petroleum Corp., 122 E. 42nd St., New York.
Macasphalt Corporation of America, 34-03 Lawrence St., Flushing, N. Y.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

PAVEMENT BREAKERS

Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.
Ingersoll-Rand Company, 11 Broadway, New York.

PAVEMENTS, TAR

The Barrett Company, 40 Rector St., New York, N. Y.

PAVERS, ROAD OR STREET

The T. L. Smith Co., 2835 N. 32nd St., Milwaukee, Wis.

PAVING GUARDS, STEEL

Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.

PHOTOGRAPHY, AERIAL AND COMMERCIAL

Abrams Aerial Survey Corp., Lansing, Mich.

PILE DRIVERS

Industrial Brownhoist Corporation, Bay City, Mich.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Ingersoll-Rand Company, 11 Broadway, New York.

PILING, STEEL

Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.

PILING, WOOD

Southern Wood Preserving Co., Atlanta, Ga.

PIPE, ASBESTOS-CEMENT

Johns-Manville, 22 E. 40th St., New York, N. Y.

PIPE, CAST IRON

Blaw-Knox Company, Pittsburgh, Pa.
United States Pipe & Foundry Co., Burlington, N. J.

PIPE, COATING ASPHALT

Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
Johns-Manville Sales Corp., 22 E. 40th St., New York, N. Y.
The Atlantic Refining Co., 260 S. Broad St., Philadelphia Pa.

PIPE, CORRUGATED IRON
Blaw-Knox Company, Pittsburgh, Pa.

PIPE, PERFORATED
Blaw-Knox Company, Pittsburgh, Pa.

PLANERS, HIGHWAY
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
The Burch Corporation, Crestline, Ohio.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

PLANERS, ROAD
Blaw-Knox Company, Pittsburgh, Pa.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

PLATES, CENTER PAVING
Truscon Steel Company, Youngstown, O.
Heltzel Steel Form & Iron Co., Warren, O.
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.
American Steel & Wire Co., 208 S. La Salle St., Chicago, Ill.

PLOWS, GRADING
Blaw-Knox Company, Pittsburgh, Pa.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

PLOWS, GRADING, ROADS, ROOTER
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.
The Galion Iron Works & Mfg. Co., Galion, O.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
The Burch Corporation, Crestline, Ohio.

PLOWS, SNOW
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Anderson Engineering Co., Statler Bldg., Boston, Mass.
The Burch Corporation, Crestline, Ohio.
Blaw-Knox Company, Pittsburgh, Pa.
Good Roads Machinery Corp., Kennett Square, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.
Carl H. Frink, Mfr., 205-225 Webb St., Clayton, N. Y.

POSTS, FENCE
American Steel & Wire Co., 208 S. La Salle St., Chicago.
Southern Wood Preserving Co., Atlanta, Ga.

POSTS, MARKER
American Steel & Wire Co., 208 S. La Salle St., Chicago.
Southern Wood Preserving Co., Atlanta, Ga.

POSTS, SIGN
American Steel & Wire Co., 208 S. La Salle St., Chicago.
Southern Wood Preserving Co., Atlanta, Ga.

POTS, POURING
Tarrant Manufacturing Co., 12 Maple Ave., Saratoga Springs, N. Y.

POWDER, BLASTING
(See EXPLOSIVES.)

POWER UNITS, GASOLINE
Hercules Motors Corporation, Canton, Ohio.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
International Harvester Co., 606 S. Michigan Ave., Chicago, Ill.
Fairbanks, Morse & Co., 900 S. Wabash, Chicago, Ill.

POWER UNITS, KEROSENE
Hercules Motors Corporation, Canton, Ohio.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
International Harvester Co., 606 S. Michigan Ave., Chicago, Ill.
Fairbanks, Morse & Co., 900 S. Wabash, Chicago, Ill.

POWER UNITS, DIESEL
Hercules Motors Corporation, Canton, Ohio.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
International Harvester Co., 606 S. Michigan Ave., Chicago, Ill.
Fairbanks, Morse & Co., 900 S. Wabash, Chicago, Ill.

POWER UNITS, INTERNAL COMBUSTION
Hercules Motors Corporation, Canton, Ohio.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
International Harvester Co., 606 S. Michigan Ave., Chicago, Ill.
Fairbanks, Morse & Co., 900 S. Wabash, Chicago, Ill.

POWER UNITS, NATURAL GAS
Hercules Motors Corporation, Canton, Ohio.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
International Harvester Co., 606 S. Michigan Ave., Chicago, Ill.
Fairbanks, Morse & Co., 900 S. Wabash, Chicago, Ill.

PRESERVATIVES, WOOD
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
Skelly Oil Company, 2534 Madison, Kansas City, Mo.
The Grasselli Chemical Co., Inc., 629 Euclid Ave., Cleveland, Ohio.
The Barrett Company, 40 Rector St., New York, N. Y.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.

PULLERS, CAR, TRUCK, ETC.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

PULVERIZERS, LIMESTONE
Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.
Day Pulverizer Company, Knoxville, Tenn.

PULVERIZERS, STONE
Day Pulverizer Company, Knoxville, Tenn.

PUMPS, ASPHALT AND TAR
Tarrant Manufacturing Co., 12 Maple Ave., Saratoga Springs, N. Y.

PUMPS, CONTRACTORS'
Ingersoll-Rand Company, 11 Broadway, New York.
C. H. & E. Mfg. Co., Inc., 120 E. Mineral St., Milwaukee, Wis.
Fairbanks, Morse & Co., 900 S. Wabash, Chicago, Ill.

PUMPS, DIAPHRAGM
C. H. & E. Mfg. Co., Inc., 120 E. Mineral St., Milwaukee, Wis.

PUMPS, TRIPLEX
C. H. & E. Mfg. Co., Inc., 120 E. Mineral St., Milwaukee, Wis.
Fairbanks, Morse & Co., 900 S. Wabash, Chicago, Ill.

RAIL FILLER
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, O.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.

RAILS, HIGHWAY GUARD
Tuthill Spring Co., 760 Polk St., Chicago, Ill.
American Steel & Wire Co., 208 S. La Salle St., Chicago.
Southern Wood Preserving Co., Atlanta. Ga.
Page Steel and Wire Division, American Chain Co., Inc., Monessen, Pa.
Truscon Steel Company, Youngstown, O.

RAILS, INSULATION
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.

RAILWAYS AND EQUIPMENT, INDUSTRIAL
Cleveland Tractor, Cleveland, Ohio.

RAKES, STONE, POWER
York Modern Corporation, Cor. Mill and Watson Sts., Unadilla, N. Y.

RIPPERS, GRADE
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Continental Roll & Steel Foundry Co., Industrial Equip. Inc., 332 S. Michigan Ave., Chicago, Ill.
The Galion Iron Works & Mfg. Co., Galion, O.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

ROAD ASPHALT
Macasphalt Corporation, 34-03 Lawrence St., Brooklyn, N. Y.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
The Texas Company, 135 E. 42nd St., New York, N. Y.
The Atlantic Refining Co., 260 S. Brook St., Philadelphia, Pa.

ROAD GRADERS
(See GRADERS, ROAD.)

ROAD OIL HEATERS
Cleaver-Brooks Company, 2784 N. 32nd St., Milwaukee, Wis.

ROAD TAR
The Barrett Company, 40 Rector St., New York, N. Y.

ROCK CRUSHERS
Blaw-Knox Company, Pittsburgh, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

ROLLERS, ROAD
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
The Huber Mfg. Co., Marion, Ohio.
Blaw-Knox Company, Pittsburgh, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.

ROLLERS, ROAD, GASOLINE
Blaw-Knox Company, Pittsburgh, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

ROLLERS, TANDEM
Blaw-Knox Company, Pittsburgh, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

ROOFING, ASPHALT
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.

ROOTERS, ROAD
Blaw-Knox Company, Pittsburgh, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

ROPE, WIRE
American Steel & Wire Co., 208 S. La Salle St., Chicago.
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.

ROTARY SNOW SHOVELS
Zaremba Snow Rooters, 29 E. Market St., Buffalo, N. Y.

ROTATING LIFTS, TRUCK TYPE
(See LIFTS, ROTATING, TRUCK TYPE.)

RUBBER CENTER JOINT
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.

RUBBER EXPANSION JOINTS
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.

SAFETY TREADS
Blaw-Knox Company, Pittsburgh, Pa.
Truscon Steel Company, Youngstown, O.

SALAMANDERS, OIL-BURNING TYPE
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

SAND BLASTS
The Gunitor Company, 1227 W. Beardsley Ave., Elkhart, Ind.

SAND AND GRAVEL HANDLING EQUIPMENT
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

SAND AND GRAVEL HANDLING MACHINERY
Blaw-Knox Company, Pittsburgh, Pa.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

SAW RIGS, PORTABLE
C. H. & E. Mfg. Co., Inc., 120 E. Mineral St., Milwaukee, Wis.

SAWS
Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis, Mo.

SCALES, FOR MATERIAL HANDLING
Heltzel Steel Form & Iron Co., Warren, O.
Fairbanks, Morse & Co., 900 S. Michigan Ave., Chicago, Ill.

SCARIFIERS
Blaw-Knox Company, Pittsburgh, Pa.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
The Galion Iron Works & Mfg. Co., Galion, O.

SCARIFIERS, TRACTOR
Blaw-Knox Company, Pittsburgh, Pa.

SCOOPS, WHEELED
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
W. A. Riddell Company, Bucyrus, O.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, AUTOMATIC
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, AUTOMATIC REVOLVING
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, DRAG
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
The Burch Corporation, Crestline, Ohio.
Blaw-Knox Company, Pittsburgh, Pa.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, DRAG, HORSE

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

SCRAPERS, DRAG, POWER

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

Blaw-Knox Company, Pittsburgh, Pa.

Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

Sauerman Bros., 438 S. Clinton St., Chicago, Ill.

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, FRESNO

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, FRESNO, HORSE

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

SCRAPERS, TRACTOR

Blaw-Knox Company, Pittsburgh, Pa.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

SCRAPERS, POWER

Blaw-Knox Company, Pittsburgh, Pa.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

Sauerman Bros., 438 S. Clinton St., Chicago, Ill.

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, REVOLVING, POWER

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

SCRAPERS, REVOLVING, TRACTOR

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, SELF-LOADING

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

Sauerman Bros., 438 S. Clinton St., Chicago, Ill.

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, SLIP

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

The Galion Iron Works & Mfg. Co., Galion, O.

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, SLIP SCOOP

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

The Galion Iron Works & Mfg. Co., Galion, O.

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, TRACTOR

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

The Galion Iron Works & Mfg. Co., Galion, O.

Sauerman Bros., 438 S. Clinton St., Chicago, Ill.

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, TRUCK ATTACHED

Root Spring Scraper Co., 527 W. North St., Kalamazoo, Mich.

The Burch Corporation, Crestline, Ohio.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

SCRAPERS, WHEELED

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

The Galion Iron Works & Mfg. Co., Galion, O.

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

SCRAPERS, WHEELED, HORSE

J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

The Galion Iron Works & Mfg. Co., Galion, O.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

SCREENING PLANTS, SAND AND GRAVEL

Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

Good Roads Machinery Corp., Kennett Square, Pa.

Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

SCREENS, CRUSHED STONE

Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

Good Roads Machinery Corp., Kennett Square, Pa.

Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

SCREENS, GRAVEL WASHING

Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

Good Roads Machinery Corp., Kennett Square, Pa.

SCREENS, REVOLVING

Good Roads Machinery Corp., Kennett Square, Pa.

Universal Crusher Company, 641 "C" Ave. West, Cedar Rapids, Iowa.

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

SCREENS, SAND, GRAVEL AND COAL

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

SCREENS, SEWAGE

Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

SCREENS, SHAKING

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

SCREENS, VIBRATING

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

Blaw-Knox Company, Pittsburgh, Pa.

SCREENS, REVOLVING

The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

Blaw-Knox Company, Pittsburgh, Pa.

SEWAGE DISPOSAL EQUIPMENT

Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

Fairbanks, Morse & Co., 900 S. Wabash, Chicago, Ill.

Allis-Chalmers Mfg. Co., Milwaukee, Wis.

SHEAVES
American Steel & Wire Co., 208 S. La Salle St., Chicago.
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.

SHOVEL PARTS
Bucyrus-Erie Company, South Milwaukee, Wis.

SHOVELS, DIESEL
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Bucyrus-Erie Company, South Milwaukee, Wis.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

SHOVELS, ELECTRIC
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Bucyrus-Erie Company, South Milwaukee, Wis.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

SHOVELS, ELECTRIC, CRAWLER, TRACTION
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Bucyrus-Erie Company, South Milwaukee, Wis.

SHOVELS, GASOLINE
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
Bucyrus-Erie Company, South Milwaukee, Wis.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

SHOVELS, GASOLINE, CRAWLER TRACTION
Industrial Brownhoist Corporation, Bay City, Mich.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
Bucyrus-Erie Company, South Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

SHOVELS, ROTARY
Zaremba Snow Rooters, 29 E. Market St., Buffalo, N. Y.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

SHOVELS, STEAM, CRAWLER TRACTION
Industrial Brownhoist Corporation, Bay City, Mich.
Bucyrus-Erie Company, South Milwaukee, Wis.

SIGN POSTS, HIGHWAY
American Steel & Wire Co., 208 S. La Salle St., Chicago.
Southern Wood Preserving Co., Atlanta, Ga.

SIGNS AND SIGNALS, TRAFFIC
The Toledo Pressed Steel Co., 397 Phillips Ave., Toledo, Ohio.

SILICATE OF SODA
Philadelphia Quartz Co., 127 S. Third St., Philadelphia.
The Grasselli Chemical Co., Inc., 629 Euclid Ave., Cleveland, Ohio.

SKIPS
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

SLINGS, WIRE ROPE
American Steel & Wire Co., 208 S. La Salle St., Chicago.
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.

SNOW FENCE POSTS
American Steel & Wire Co., 208 S. La Salle St., Chicago.

SNOW PLOWS, TRUCK AND TRACTOR
Cleveland Tractor, Cleveland, Ohio.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Carl H. Frink, Mfr., 205-225 Webb St., Clayton, N. Y.
Anderson Engineering Co., Statler Bldg., Boston, Mass.
Root Spring Scraper Co., 527 W. North St., Kalamazoo, Mich.
The Burch Corporation, Crestline, Ohio.
Good Roads Machinery Corp., Kennett Square, Pa.
The Galion Iron Works & Mfg. Co., Galion, O.

SNOW ROOTERS
Zaremba Snow Rooters, 29 E. Market St., Buffalo, N. Y.

SNOW REMOVAL MACHINERY
Blaw-Knox Company, Pittsburgh, Pa.
Zaremba Snow Rooters, 29 E. Market St., Buffalo, N. Y.

SODIUM SILICATE
Philadelphia Quartz Co., 127 S. Third St., Philadelphia.
The Grasselli Chemical Co., 629 Euclid Ave., Cleveland, O.

SPACERS, SLAB, CONCRETE
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.
Heltzel Steel Form & Iron Co., Warren, O.

SPADERS, CLAY
Sullivan Machinery Co., 400 N. Michigan Ave., Chicago.

SPRAYERS, ASPHALT EMULSION
Hauck Manufacturing Company, 110-140 Tenth St., Brooklyn, N. Y.
Tarrant Manufacturing Co., 12 Maple Ave., Saratoga Springs, N. Y.

SPREADERS, GRAVEL, STONE AND SAND
Anderson Engineering Co., Statler Bldg., Boston, Mass.
The Burch Corporation, Crestline, Ohio.
Blaw-Knox Company, Pittsburgh, Pa.
Good Roads Machinery Corp., Kennett Square, Pa.
Flexible Road Joint Machine Co., Warren, O.
The Galion Iron Works & Mfg. Co., Galion, O.

SPRINKLERS, HIGHWAY AND STREET
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
E. D. Etnyre & Co., Oregon, Ill.

SPRINGS, AUTO AND TRUCK
Tuthill Spring Co., 760 Polk St., Chicago, Ill.

SPRINGS, AUXILIARY OR HELPER
Tuthill Spring Co., 760 Polk St., Chicago, Ill.

SPRING STEEL BARS
Tuthill Spring Co., 760 Polk St., Chicago, Ill.

SPRING STEEL BRACKETS
Tuthill Spring Co., 760 Polk St., Chicago, Ill.

SPROCKETS
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill

STABILIZED GRAVEL ROADS
Calcium Chloride Association (for list of members, see CALCIUM CHLORIDE).

STEEL FABRIC, WELDED
American Steel & Wire Co., 208 S. La Salle St., Chicago.
Truscon Steel Company, Youngstown, O.
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.

STEEL PLATE GUARD RAIL
Tuthill Spring Co., 760 Polk St., Chicago, Ill.
Truscon Steel Company, Youngstown, O.

STOKER
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

STREET NAME SIGNS
Municipal Street Sign Co., Inc., 299 Broadway, New York, N. Y.

STRIKE-OFFS AND TEMPLATES
Blaw-Knox Company, Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.

STRIPS, ROAD, METAL
Heltzel Steel Form & Iron Co., Warren, O.
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.

Highway Steel Products Co., 1324 McKinley St., Chicago Heights, Ill.
American Steel & Wire Co., 208 S. La Salle St., Chicago, Ill.

STRIPS, PINS AND ACCESSORIES FOR CONCRETE ROAD AND REINFORCEMENT
Highway Steel Products Co., 1324 McKinley St., Chicago Heights, Ill.
Kalman Steel Company (Subsidiary of Bethlehem Steel Corp.), Bethlehem, Pa.

STUMP PULLERS
Cleveland Tractor, Cleveland, Ohio.

SUBGRADE PAPER
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.

SUBGRADE TESTERS
Blaw-Knox Company, Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.

SURVEYS, AERIAL
Abrams Aerial Survey Corp., Lansing, Mich.

SWEEPERS, STREET
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
The Frank G. Hough Company, 919 N. Michigan Ave., Chicago, Ill.

TAMPERS, BACKFILL
Ingersoll-Rand Company, 11 Broadway, New York.

TANK CAR HEATERS
Cleaver-Brooks Co., Milwaukee, Wis.

TANK TRAILERS
C. R. Jahn Co. (La Crosse Trailers), 228 N. La Salle St., Chicago, Ill.

TANKS, WELDED AND RIVETED
Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis, Mo.
Heltzel Steel Form & Iron Co., Warren, O.
The Jos. Honhorst Co., 1016 W. Sixth St., Cincinnati, O.

TAR KETTLES, FOR ROAD CONTRACTORS
The Jos. Honhorst Co., 1016 W. Sixth St., Cincinnati, O.
Good Roads Machinery Corp., Kennett Square, Pa.
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

TAR, ROAD
The Barrett Company, 40 Rector St., New York, N. Y.

TAR AND PITCH, PAVING
The Barrett Company, 40 Rector St., New York, N. Y.

THAWING OUTFITS AND TORCHES
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

TIPPLES
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

TIRE INFLATION STANDS
Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis, Mo.

TOPOGRAPHERS, AERIAL SURVEY
Abrams Aerial Survey Corp., Lansing, Mich.

TORCHES, GASOLINE AND KEROSENE
The Toledo Pressed Steel Co., 397 Phillips Ave., Toledo, Ohio.
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.
White Mfg. Co., 1227 W. Beardsley Ave., Elkhart, Ind.

TRACTOR HITCHES
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

TRACTOR TRUCKS
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.

TRACTORS, CRAWLER
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Cleveland Tractor, Cleveland, Ohio.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

TRACTORS, WHEEL TYPE
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.
The Huber Manufacturing Co., Marion, Ohio.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

TRACTOR WAGONS AND TRAILERS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

TRAFFIC LINE EQUIPMENT
Flexible Road Joint Machine Co., Warren, O.

TRAILBUILDERS
Continental Roll & Steel Foundry Co., Industrial Equip. Inc., 332 S. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

TRAILERS
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.
C. R. Jahn Co. (La Crosse Trailers), 228 N. La Salle St., Chicago, Ill.

TRAILERS—FLAT PLATFORM
C. R. Jahn Co. (La Crosse Trailers), 228 N. La Salle St., Chicago, Ill.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

TRAILERS—FULLY REVERSIBLE
C. R. Jahn Co. (La Crosse Trailers), 228 N. La Salle St., Chicago, Ill.

TRAILERS FOR MOTOR TRUCKS
C. R. Jahn Co. (La Crosse Trailers), 228 N. La Salle St., Chicago, Ill.

TRAILERS—DROP FRAME TYPE
C. R. Jahn Co. (La Crosse Trailers), 228 N. La Salle St., Chicago, Ill.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

TRAILERS, MACHINERY
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
C. R. Jahn Co. (La Crosse Trailers), 228 N. La Salle St., Chicago, Ill.

TRAILERS—SEMI
C. R. Jahn Co. (La Crosse Trailers), 228 N. La Salle St., Chicago, Ill.

TRAILERS FOR TRACTORS
C. R. Jahn Co. (La Crosse Trailers), 228 N. La Salle St., Chicago, Ill.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.
International Harvester Co. of America, 606 S. Michigan Ave., Chicago.

TRAILERS FOR SHOVELS AND CRANES
C. R. Jahn Co. (La Crosse Trailers), 228 N. La Salle St., Chicago, Ill.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

TRAILER SPRINGS
Tuthill Spring Co., 760 Polk St., Chicago, Ill.

TRANSMISSION EQUIPMENT, POWER
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

TREADS, TRAFFIC SAFETY
Blaw-Knox Company, Pittsburgh, Pa.
Truscon Steel Company, Youngstown, O.

TRUCKS, CONCRETE MIXER
Blaw-Knox Company, Pittsburgh, Pa.
T. L. Smith Company, 2835 N. 32nd St., Milwaukee, Wis.

TRUCKS, HAND
Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago.

TRUCKS, MOTOR
International Harvester Co. of America, 606 S. Michigan Ave., Chicago, Ill.

TRUCK SPRINGS
Tuthill Spring Co., 760 Polk St., Chicago, Ill.

TUBING, FLEXIBLE METALLIC
Chicago Tubing & Braiding Co., Maywood, Ill.
Highway Steel Products Co., 1324 McKinley St., Chicago Heights, Ill.
Titeflex Metal Hose Co., 500 Frelinghuysen Ave., Newark, N. J.

TURNBUCKLES
American Steel & Wire Co., 208 S. La Salle St., Chicago.

TURNTABLES, MOTOR TRUCK
Blaw-Knox Company, Pittsburgh, Pa.

UNLOADERS, WAGON AND CAR
Blaw-Knox Company, Pittsburgh, Pa.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.
The Burch Corporation, Crestline, O.

VEHICLE LEAF SPRINGS
Tuthill Spring Co., 760 Polk St., Chicago, Ill.

WAGONS, DUMP
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.

WAGONS, DUMP, CRAWLER TREAD
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

WASHERS, AUTOMOBILE AND TRUCK TYPE
Curtis Pneumatic Machinery Co., 1913 Kienlen Ave., St. Louis, Mo.

WASHING PLANTS, SAND AND GRAVEL
Universal Crusher Co., 641 "C" Ave. West, Cedar Rapids, Iowa.
The Austin-Western Road Machinery Co., 400 N. Michigan Ave., Chicago, Ill.
Good Roads Machinery Corp., Kennett Square, Pa.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

WASHING PLANTS, SAND AND GRAVEL, PORTABLE
Universal Crusher Co., 641 "C" Ave. West, Cedar Rapids, Iowa.
The Austin-Western Road Machinery Co., 400 N Michigan Ave., Chicago, Ill.

WATER HEATERS FOR CONCRETE MIXERS
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.
Mexican Petroleum Corp., 122 E. 42nd St., New York.
The Barrett Company, 40 Rector St., New York.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
The Texas Company, 135 E. 42nd St., New York, N. Y.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, O.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.

WEED BURNERS
Hauck Mfg. Co., 110-140 Tenth St., Brooklyn, N. Y.

WEIGHING MACHINES, MATERIAL
Blaw-Knox Company, Pittsburgh, Pa.
Heltzel Steel Form & Iron Co., Warren, O.

WELDERS
Cleveland Tractor, Cleveland, Ohio.
Harnischfeger Corporation, 4485 W. National Ave., Milwaukee, Wis.
J. D. Adams Company, 217 S. Belmont Ave., Indianapolis, Ind.

WHEELS, SPROCKET
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

WINCHES
Cleveland Tractor, Cleveland, Ohio.
Link-Belt Company, 300 W. Pershing Rd., Chicago, Ill.

WINGS, SNOW PLOW SIDE
Carl H. Frink, Mfr., 205-225 Webb St., Clayton, N. Y.

WIRES AND CABLES
American Steel & Wire Co., 208 S. La Salle St., Chicago.
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.

WIRE ROPE
A. Leschen & Sons Rope Co., 5909 Kennerly Ave., St. Louis, Mo.
American Steel & Wire Co., 208 S. La Salle St., Chicago, Ill.

WATERPROOFING COMPOUNDS AND MATERIAL
The Atlantic Refining Co., 260 S. Broad St., Philadelphia Pa.
Johns-Manville Sales Corp., 22 E. 40th St., New York.
The Texas Company, 135 E. 42nd St., New York, N. Y.
The Grasselli Chemical Co., Inc., 629 Euclid Ave., Cleveland, Ohio.
Mexican Petroleum Corp., 122 E. 42nd St., New York.
The Barrett Company, 40 Rector St., New York, N. Y.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Servicised Products Corp., 6051 W. 65th St., Chicago, Ill.
Standard Oil Company of Indiana, 910 S. Michigan Ave., Chicago, Ill.
Standard Oil Co. of New York, 26 Broadway, New York, N. Y.

WATERPROOFING PAINTS
The Texas Company, 135 E. 42nd St., New York.
Mexican Petroleum Corp., 122 E. 42nd St., New York.
The Barrett Company, 40 Rector St., New York, N. Y.
The Philip Carey Company, Wayne Ave., Lockland, Cincinnati, Ohio.
Truscon Laboratories, Detroit, Mich.
The Atlantic Refining Co., 260 S. Brook St., Philadelphia, Pa.

WATERPROOFING PROTECTION
Johns-Manville Sales Corp., 22 E. 40th St., New York.
The Gunitor Company, 1227 W. Beardsley Ave., Elkhart, Ind.

POWERS' ROAD AND STREET CATALOG

DIRECTORY OF

DEALERS IN HIGHWAY CONTRACTORS' EQUIPMENT AND SUPPLIES

Arranged by States

ALABAMA

C. B. Davis Engr. Co., 1000 43rd St., Birmingham.

G. C. Phillips Tractor Co., Inc., 1625-31 Ave. B, South Birmingham.

J. D. Pittman Tractor Co., Inc., 520-26 N. 28th St., Birmingham.

Turner Supply Company, N. W. Cor. of St. Louis and Commerce Sts., Mobile.

ARIZONA

Arizona Tractor & Equipment Co
138 So. First Ave. Phoenix, Arizona

Representing

"CATERPILLAR" Tractors
"CATERPILLAR" Road Machinery
ATECO Dirtmovers, Bulldozers, Tamping Rollers and Scarifiers
ATHEY Truss Wheels
BUFFALO-SPRINGFIELD Rollers
DAY Crushers
HEIL Hoists
KILLEFER Road Tools
LaPLANT-CHOATE Snow Plows
LITTLEFORD Asphalt Equipment
PACIFIC Wire Rope
SPEEDER Shovels
WILLIAMETTE-ERSTED Hoists
EUCLID Earth Moving Equipment

Neil B. McGinnis Company, Box 2113, 753 E. Jackson St., Phoenix.

Mine & Smelter Equipt. Company, 306-12 S. 7th Ave., Phoenix.

Ronstadt Hardware & Machinery Co., Tucson.

ARKANSAS

Arkansas Foundry Company, Iron and Steel, Little Rock.

Kern-Limerick, Inc., 115 N. Spring St., Little Rock.

CALIFORNIA

The Brown-Bevis Co., 49th St. and Santa Fe Ave., Los Angeles.

Concrete Machy. & Supply Co., 777 E. Gage Ave., Los Angeles.

Crook Company, 2900 Santa Fe Ave., Los Angeles.

Garlinghouse Bros., 2416 E. 16th St., Los Angeles.

Shepherd Tractor and Equipt Co., 514-20 W. 12th St., Los Angeles.

Smith Booth Usher Company, 2001 Santa Fe Ave., Los Angeles.

Edward R. Bacon Company, Folsom at 17th St., San Francisco.

Norris K. Davis, Inc., 400 Seventh St., San Francisco.

Garfield & Company, Hearst Building, San Francisco.

Jenison Machinery Co., 20th and Tennessee Sts., San Francisco.

KRATZ & McCLELLAND, Inc.
522 Bryant St. San Francisco, Calif.

Northern California Distributors

Ransome Concrete Machy. Co.—Pavers, Mixers, Towers, Chuting
Novo Engine Co.—Engines, Hoists, Pumps, Lighting Units
White Mfg. Co.—Portable Asphalt Plants, Kettles
Greyhound—Contractors' Portable Saws
Heltzel Steel Form & Iron Co.—Bins, Batchers, Road Forms
Ames Iron Works—Gasoline Road Rollers
Union Iron Works Inc.—Pile Hammers and Foundation Equip.
Lidgerwood Mfg. Co.—Hoists, Winches, Cableways
N. P. Nelson Iron Works—Loaders, Conveying Equipment
The Gunitor Co.—Pneumatically-Placed Concrete
Wisconsin Fdry. & Mach. Co.—Crushers, Screens, Plants
C. R. Jahn Co.—LaCrosse "TU-WAY" Trailers

COLORADO

Elton T. Fair Co., 1611 Wazee St., Denver.

Paul Fitzgerald, U. S. National Bank Bldg., Denver.

Hendrie & Bolthoff Mfg. & Supply Co., 1635 Seventeenth St., Denver.

Herbert N. Steinbarger Co., 1640-1646 Wazee St., Denver.

CONNECTICUT

The K. B. Noble Co., Hartford.

The Gesner Equipment Corp., 254 Park St., New Haven.

Power Equipment & Service, Inc., 109 Water St., New Haven.

CUBA

Milian Machinery Co., S. A., Havana.

WASHINGTON, D. C.

The Henry H. Meyer Co., 658 Munsey Bldg., Washington; 110 S. Howard St., Baltimore, Md.

FLORIDA

Julian P. Benjamin, 21 N. Ocean St., Jacksonville.

Farquhar Machinery Co., 720 W. Bay St., Jacksonville.

M. D. Moody, ACL No. 2—Sect. L, Riverside Viaduct, Jacksonville.

McDonald Tractor Equip. Co., 2303 N. Orange Ave., Orlando.

GEORGIA

Yancey Tractor Company, 109-113 Booker Ave., Albany.

R. S. Armstrong & Bro. Co., 676 Marietta St., Atlanta.

Tractor & Machinery Co., Inc., 351 Whitehall St., S. W., Atlanta.

Yancey Brothers, Inc., 634 Whitehall St., S. W., Atlanta.

ILLINOIS

Hamilton Tractor & Equipment Co., 411-419 N. Illinois, Carbondale.

Paul Cochran Equipment Co., 228 N. La Salle St., Chicago.

F. H. Burlew Company, 221-225 W. Huron St., Chicago.

W. B. Louer Company, 431-5 S. Jefferson St., Chicago.

Superior Constr. Equip. Co., 1850 S. Kostner Ave., Chicago.

Tractor & Equipment Co., 551 W. Van Buren St., Chicago.

Western Contractors Supply Co., 14 N. Clinton St., Chicago.

Peoria Tractor & Equipment Co., 400 Franklin St., Peoria.

INDIANA

Bowman-Ralston Tractor & Equipment Co., 401 E. Florida St., Evansville.

S & L Equipment Company, Fort Wayne.

Stockberger Equipment Co., 1211 1st and Tri-State Bldg., Fort Wayne.

Standard Equipment & Supply Corp., successor to McLaughlin Mill Supply Co., Inc., 534 Michigan Ave., Hammond.

Shearer & Mayer, 712 W. 13th St., Indianapolis.

IOWA

Gierke-Robinson Company, 4th and Ripley Sts., Davenport.

Herman M. Brown Co., Des Moines.

Dukehart Machinery Co., 106 W. Second St., Des Moines.

KENTUCKY

Wilson Machinery & Supply Co., Inc., 139-51 N. Mill St., Lexington.

Brandeis Machinery & Supply Co., 201 Warnock St., Louisville.

Roy C. Whayne Supply Co., 8th and Main Sts., Louisville.

THOMAS L. BARRET
112-114 So. Second St. Louisville, Ky.

Representing

"C. H. & E." "Portable" Pumps, Hoists, Saw Rigs, etc.
"Russell" Scrapers
"Knickerbocker" Concrete Mixers
"Kalman" Steel
"Bay City" Shovels
"Pioneer" Asphalt Crack & Joint Filler
"Kennedy" Crushers, Screens, Elevators
"Shunk" Gravity Dump Tractors
"Union" Pile Drivers
"Thor" Air Compressors
"Barret" Bronze Expansion Plates
"Williams" Buckets
"Armstrong" Drills
"LaCrosse" "Tu-Way" Trailers
"Haiss" Digger Loaders and Conveyors
"Barret" Asphalt Expansion Joint
"Mundy" Hoists
"Erie" Aggremeter Plants and Bins
"Archer" Hoist Tower Outfits
"Metaform" Road Rails
"Hug" Road Trucks
"De Walt" Electric Saws

Joe C. Tucker

Morganfield **Kentucky**

Representing

AUSTIN-WESTERN RD. MACHY. CO.
CLEVELAND TRACTOR CO.
WESTERN WHEELER SCRAPER CO.
HARNISCHFEGER CORPORATION
LAKEWOOD ENGINEERING CO.
A. B. FARQUHAR, LTD.
CHAIN BELT CO.
LINK-BELT CO.
SULLIVAN MACHY. CO.
BUTLER BIN CO.
EUCLID RD. MACHY. CO.
HUGHES-KEENAN CO.

HENRY A. PETTER SUPPLY CO.

Paducah **Kentucky**

Alemite Equipment
American Wire Rope, Mesh
Bates Bar Ties
Beebe Hand Hoists
Black & Decker Tools
Cedar Rapids Crushers
Chain Belt (Rex) Mixers
D-A Lubricants
DuPont Explosives
Dobbie Derricks
Elastite Expansion Joint
Farquhar Engines, Boilers
Gulf States Reinforcing Steel
Hansen Excavators
Hauck Heaters and Thawers
Johnson Bins and Hoppers
Lidgerwood Hoisting Machinery
Lincoln Electric Motors
Link-Belt Portable Conveyors
LeRoi Gas Engines
Northwest Shovels, Cranes
Novo Pumps and Hoists
Oxweld Apparatus
Page Buckets
Rogers Bros. Trailers
Sasgen Derricks
Shunk Grader Blades
Toledo Torches
Trackson Tractors
Universal Conc. Accessories
Vulcan Pile Equip.
Wehr Graders
Western Road Machy.
Worthington Pumps
Wyoming Shovels

LOUISIANA

Easton Tractor & Equipment Co., Lee and Harris Sts., Alexandria.

Fletcher Equipment Co., Inc., 309 Magazine St., New Orleans.

Equitable Equipment Co., Inc., 410 Camp St., New Orleans.

Louisiana Road Machinery Co., Inc., 1111 Julia St., New Orleans.

Southern States Equip. Co., Inc., 1510-30 Tchoupitoulas St., New Orleans.

Builders Supply Co., Inc., P. O. Box 295, Shreveport.

MAINE

Northern Road Equipment Co., 82 St. John St., Portland.

MARYLAND

ALBAN TRACTOR CO., Inc.

725-727 E. 25th St. Baltimore, Md.

Representing

CATERPILLAR TRACTORS AND ROAD MACHINERY
LINK-BELT SHOVELS AND CRANES
EUCLID ROAD MACHINERY CO.
GENERAL EXCAVATOR CO.
KILLEFER MANUFACTURING CORP.
LAPLANT-CHOATE MANUFACTURING CO.
WILLAMETTE-ERSTED CO.
BABCOCK MANUFACTURING CO.
ATHEY TRUSS WHEEL CO.
BARNES MANUFACTURING CO.
CLEVELAND ROCK DRILL CO.
HERCULES ROLLER CO.
BLAW-KNOX COMPANY
PIONEER GRAVEL EQUIPMENT MFG. CO.
ERIE STEEL CONSTRUCTION CO.
GRAVELY MOTOR PLOW & CULTIVATOR CO.

Thos. M. Brown, Inc., 106 S. Gay St., Baltimore.

D. C. Elphinstone, Inc., 115 S. Calvert St., Baltimore.

John C. Louis Company, 511 W. Pratt St., Baltimore.

The Henry H. Meyer Co., 110 S. Howard St., Baltimore; 628 Munsey Bldg., Washington, D. C.

MASSACHUSETTS

The Bond Co., 39 Old Colony Ave., South Boston.

Clark-Wilcox Company, 790-798 Albany St., Boston.

P. I. Perkings Co., 376 Dorchester Ave., Boston.

The Equipment Co., 8 Gerard St., Boston.

Hedge & Mattheis Company, 285 Dorchester Ave., Boston.

M. B. Tyler Company, 344 Columbus Ave., Springfield.

MICHIGAN

Thomas G. Abrams, 2411 Fourteenth St., Detroit.

Cyril J. Burke, Great Lakes Terminal Warehouse, Detroit.

Keller Tractor & Equipment Co., Inc., 5163-69 Martin Ave., Detroit.

R. G. Moeller Company, 14415 Meyers Rd., Detroit.

E. K. S. Equipment Co., 18 Grandville Ave., S. W., Grand Rapids.

Pingry Tractor & Equipment Co., 1239 Buchanan Ave., Grand Rapids.

UPPER PENINSULA TRACTOR CO., Inc.

L'Anse **Michigan**

Representing

CATERPILLAR TRACTOR CO.
FOUR WHEEL DRIVE AUTO CO.
ROTARY SNOW PLOW CO.
WAUSAU IRON WORKS
DIAMOND IRON WORKS
LA PLANT-CHOATE MANUFACTURING CO.
GENERAL EXCAVATOR CO.
AMERICAN HOIST & DERRICK CO.
OLIVER FARM EQUIPMENT SALES CO.
BLAW-KNOX CO.
WILLIAMETTE-ERSTED CO.
KILLEFER MANUFACTURING CO.
EUCLID ROAD MACHINERY CO.
ATHEY TRUSS WHEEL CO.

MINNESOTA

Borchert-Ingersoll, Inc., St. Paul.

Minneapolis Equipment Co., 514-520 S. E. 2nd St., Minneapolis.

Thorman W. Rosholt Co., 928 S. Fourth St., Minneapolis.

Wm. H. Zeigler Co., Inc., 2331 University Ave. S. E., Minneapolis.

Northfield Iron Company, 487 Nico St., Northfield.

Lange Tractor & Equipment Co.

304 Lake Ave., S. Duluth, Minn.

Caterpillar Road Machinery and Tractors
LaPlant - Choate Wagons, Bulldozers, Snow Plows, Scrapers
Keystone Excavators, Blast Hole Drills
Diamond Gravel Crushing, Screening, Washing Plants, Conveyors
Killefer Scrapers, Road Discs, Rippers
Davey Air-Cooled Air Compressors
Cleveland Rock Drills
Lenhart Wagons
Blaw - Knox Ateco Scrapers, Bulldozers
Hanson Gas Shovels, Trailers
Williamette-Ersted Hoists and Winches
Wausau Tractor and Truck Snow Plows
Brookville Gas and Diesel Locomotives
Oshkosh Four - Wheel Drive Trucks
Anthony Power Loaders
Leach Concrete Mixers
MacWhyte Wire Rope
Highway Earth Boring Machines
Ames Baldwin Wyoming Hand Shovels

MISSOURI

John R. Key, Our 23rd Year, 1313 S. Garrison St., Carthage.

E. A. Martin Equipment Co., 501-23 School St., Joplin; 420 W. Commercial St., Springfield.

Bublitz Machinery Co., 2141 Washington St., Kansas City.

Funkhouser Equipment Co., 2425 Jefferson St., Kansas City.

Acme Equipment Co., 1510 N. 13th St., St. Louis.

Allied Construction Equipment Co., 4025 Forest Park Blvd., St. Louis.

Corby Supply Co., 3942-46 W. Pine Blvd., St. Louis.

John Fabick Tractor Co., Gravois and Iowa Aves., St. Louis.

C. F. Rabbeitt, Inc., 1523 N. Broadway, St. Louis.

The Geo. F. Smith Co., Franklin and Channing Aves., St. Louis.

Tulley Equipment Co., Inc., 4215 Clayton Ave., St. Louis.

The Lincoln Equipment & Material Co., 1510 N. 13th St., St. Louis.

MONTANA

Connelly Machinery Co., 2706 Montana Ave., Billings.

Midland Implement Co., Inc., Billings.

Hall-Perry Machinery Co., 802-12 E. Iron St., Butte.

Northwest Equipment Co., Inc., Box 1112, Great Falls.

NEBRASKA

Fuchs Equipment Co., 1124 Farnam Ave., Omaha.

Interstate Machinery & Supply Co., 1006 Douglas St., Omaha.

NEW JERSEY

C. A. Lippincott & Bros., Inc., 3rd and Union Sts., Moorestown.

Tractor & Equipment Co., 520 Passaic Ave., Newark.

Dale & Rankin, Inc., 113 Freylinghuysen Ave., Newark.

Johnson & Dealaman, Inc., 60 Marshall St., Newark.

NEW YORK

Contractors Sales Co., Inc., N. Broadway, Albany.

John R. Finklepaugh, 924 Central Ave., Albany.

Slade Tractor Co., Inc., 36 Learned St., Albany.

STERLING TRACTOR EQUIP. CO.

62 Bush St. Brooklyn, N. Y.

Representing

J. I. CASE CO., Racine, Wis.
Industrial Tractors
Full Line of Tractor Equipment
Sterling Tractor Cranes
Sterling-Tiger Tractors

H. M. Hirschfeld, 16th Ave. and 63rd St., Brooklyn.

Edward Ehrbar, Inc., 29 Naserole Ave., Brooklyn.

DOW & COMPANY, Inc.

Court & Wilkeson Sts. Buffalo, N. Y.

Representing

Thew Shovel Co.
Universal Crane Co.
T. L. Smith Co.
C. H. & E. Mfg. Co.
Rodax Corp.
Wellman Eng. Co.
International Harvester Co.
Rome Manufacturing Co.
Ames Iron Works
Mohawk Asphalt Heater Co.
Williamsport Wire Rope Co.
Shunk Mfg. Co.
D-A Lubricant Co.
Walter Motor Truck Co.
Carl H. Frink, Mfr.

Lloyd G. Ross, 3090 Main St., Buffalo.

J. H. Welch Company, Inc., 254 Court St., Buffalo.

The Wheeler Equipment Co., 242 Hopkins St., Buffalo.

Eugene F. Van Name, 116 John St., Horseheads.

George D. Case Co., Inc., Horseheads.

Complete Machinery & Equipment Co., Inc., Webster Ave. and Hancock St., Long Island.

George Malvese & Co., Jericho Turnpike, near Nassau Blvd., Garden City Park, P. O. New Hyde Park.

R. E. Brooks Company, 50 Church St., New York.

The Hubbard-Floyd Co., Inc., 167th St. and Sedgewick Ave., New York.

Brown & Sites Co., Main Office 30 Church St., New York City.

Contractors Trading Co., 232 Fulton St., New York.

A. P. Dienst Co., 140th St. and 3rd Ave., New York.

Fitzgerald Hudson, 445 W. 26th St., New York City.

J. C. Houston, 50 Church St., New York.

H. J. Hush, Inc., 509-515 W. 56th St., New York.

Mahoney-Clarke, Inc., 217 Pearl St., New York.

H. O. Penn Machinery Co., Inc., 140th St. and East River, Bronx.

Richards & Hirschfeld, Inc., 50 Church St., New York.

John Reiner & Co., Inc., 29 Howard St., New York.

C. V. Pierce Co., Inc., Bedford Road, Pleasantville.

Bashford-McCord Corp., 95 Crouch St., Rochester.

BREWSTER & WILLIAMS, Inc.

Contractors' Supplies and Equipment

306 S. Salina St. Syracuse, N. Y.

Representing

Butler Bins and Measuring Hoppers
C. H. & E. Contractors' Pumps, Hoists, Saw Rigs
Haiss Loaders, Excavators, Conveyors and Buckets
Hotchkiss Steel Forms
La Crosse Tu-Way Trailers
Littleford Asphalt Heaters and Tools
Osgood Shovels, Draglines and Cranes
Ransome Mixers, Pavers, Towers and Chutes
Sullivan Compressors, Drills and Hoists
G. S. C. Hi-Speed Spreaders

Member: Associated Equipment Distributors

Haverstick & Co., Inc., Ford and Spring Sts., Rochester.

Drake Tractor & Equipment Co., 116 S. Washington St., Rome.

The Kellam & Shaffer Co., Maxon Road, Schenectady.

THE SYRACUSE SUPPLY CO.

314 W. Fayette St. Syracuse, N. Y.

Warehouse: 358 W. Jefferson St.

Blaw-Knox Co.—Bins, Buckets, Bulldozers, Dirtmovers, Road Forms, Ord Finishing Machines, etc.
Caterpillar Tractor Co.—Tractors, Road Machines
Nat'l Equip. Co.—Shovels, Pavers, Mixers, Trenchers
Insley Mfg. Co.—Power Shovels, Mast Plants
Ingersoll-Rand Co.—Compr., Rock Drills, etc.
La Plant-Choate Mfg. Co.—Bulldozers, Dirt Movers, Crawler Wagons
Barnes Mfg. Co.—Road Pumps, Drainage Pumps
Clyde Sales Co.—Hoists, Derricks
Williamsport Wire Rope Co.—Wire Rope, Fittings
Universal Form Clamp Co.—Concrete Form Spec.
Athey Truss Wheel Co.—Crawler Wagons
Killefer Mfg. Corp.—Road-Rippers, Scrapers
Atlas Powder Co.—Dynamite, Blasting Supplies
Centaur—Hi-way Mowers
Barber Greene Co.—Conveying Equipment

Member: Associated Equipment Distributors

Miller Equipment Co., Inc., 127 Solar St., Syracuse.

Engels Tractor Co., Inc. Warehouse: 334-336 N. Genessee St., Utica.

McQuade & Bannigan, Inc., 829 Noyes St., Utica.

NORTH CAROLINA

American Hardware & Equipment Co., Charlotte.

Raleigh Tractor & Equipment Co., 108 W. Lane St., Raleigh.

Carolina Tractor & Equipment Co., S. Main Ext., Salisbury.

OHIO

The Queen City Supply Co., Pearl and Glen St., Cincinnati.

The Blaisdell-Folz Equipment Co., 205-219 W. Pearl St., Cincinnati.

The Wm. T. Johnson Co., 210-212-214 Vine St., Cincinnati.

H. P. Kelly Equipment Co., Cincinnati.

The Mechanical Supplies Co., 205-207 Vine St., Cincinnati.

The Day & Maddock Co., 8201 Almira Ave., Cleveland.

CLETRAC OHIO SALES CO.

East 193rd St. and Euclid Avenue

Cleveland, Ohio

Representing

THE CLEVELAND TRACTOR COMPANY (Tractors)
THE KILLEFER MANUFACTURING CORP. LTD. (Deep Tillage Tools)
THE ESSEX ENGINE & MACHINE CORP. (Bulldozers)
THE DAVEY COMPRESSOR COMPANY (Air Compressors)
THE NEISS & COMPANY (Bulldozers)
THE GALION IRON WORKS & MFG. CO. (Road Graders)

Industrial Engine Parts, Inc., 1053 E. 61st St., Cleveland.

Interstate Equipment Sales Corporation, Chester-Twelfth Bldg., Cleveland.

The W. M. Pattison Supply Co., 777 Rockwell Ave., Cleveland.

The Pope Equipment Co., Kent Pope, Pres., 4111 Euclid Ave., Cleveland.

J. Frank Rollings, 2215 West Blvd., Cleveland.

W. T. Walsh Equipment Co., 12500 Berea Road, Cleveland.

THE OSBORNE & SEXTON MACHINERY CO.

4th & Russell Sts. Columbus, Ohio

Representing

SCHRAMM, INC.
NOVO ENGINE CO.
TIMKEN ROLLER BEARING CO.
CLEVELAND ROCK DRILL CO.
W. A. RIDDELL CO.
UNIVERSAL CRUSHER CO.
VULCAN IRON WORKS
OHIO POWER SHOVEL CO.

THE W. W. WILLIAMS CO.

835 W. Goodale St. Columbus, Ohio

Representing

Koehring Cranes, Mixers, Pavers
C H & E Road Pumps and Saw Rigs
Insley Excavators and Tower Equip.
Gardner-Denver Compressors and Tools
Cedar Rapids Crushers and Screening Equip.
Hug Road builder Trucks
Waukesha Industrial Motors
Parsons Trenchers
Quik-Mix Mixers
Ord Finishing Machines
Blaw-Knox Bins, Forms, Buckets
F W D Truck Maintainers
Sterling Motor Trucks
Gascon Scale Equipment

Member—Associated Equipment Dealers

McNeilly Machinery Co., 146 S. Yale Ave., Columbus.

Smith & Elliott, Inc., 644 N. Fourth St., Columbus.

C. L. Stith Company, 305 Franklin Bldg., Columbus.

The Taylor Tractor Co., 285 Cozzens St., Columbus.

Ohio Valley Machinery Co., Marietta.

J. Walker Wilson, P. O. Box 1084, Youngstown.

SOUTHERN OHIO EQUIPMENT CO

212-214 First National Bank Bldg.

Zanesville, Ohio

Representing

THE AUSTIN-WESTERN ROAD MACHINERY CO.
CLEVELAND TRACTOR CO.
THE D-A LUBRICANT CO., INC.
SCHRAMM, INC.
THE OSGOOD CO.
THE GENERAL EXCAVATOR CO.
SAUERMAN BROS., INC.
Culvert Pipe Repairs for all makes machinery

OKLAHOMA

The Boardman Co., Oklahoma City.

OREGON

Bunting Tractor Co., La Grande.

The Balzer Machinery Co., 275 Pine St., Portland.

Feenaughty Machinery Co., 320 Belmont St., Portland.

Western Road Machinery Co., 220 E. Water St., Portland.

Clyde Equipment Co., Portland, Ore., Seattle, Wash.

Howard-Cooper Corporation, Portland-Seattle-Spokane-Twin Falls.

LELAND EQUIPMENT CO

Tulsa **Okla. City**

Representing

Koehring Pavers, Shovels, Cranes, Mixers, Mud Jacks, Dumptors
Insley Mast Hoists, Building Towers, Excavators
Parsons Ditchers
C. H. & E. Pumps, Saw Rigs, Hoists, Ditchers
Cedar Rapids Crushers, Gravel Plants, Bituminous Mixer Plants
Huber Road Rollers
Riddell Graders and Maintainers
Schramm Air Compressors, Welders
Cleveland Rock Drills, Paving Breakers, Air Tools
Crucible Steel and Bits
St. Paul Hoists, Dump Bodies
Anthony Hoists, Dump Bodies
Ames-Baldwin-Wyoming Shovels
Sterling Wheelbarrows, Carts
Rex-Watson Wagons
Standard Tar Heaters and Tools
McKiernan-Terry Pile Hammers and Tools
Link Belt Loaders, Conveyors, Elevators
Airoil Concrete Heaters and Burners
Sterling Pumps and Hoists
Dietz Torches
Rosco Road Oilers and Distributors
Page Dragline Buckets
Sauerman Dragline and Cableway Equipment
Roebling Wire Line

Mitchell, Lewis & Staver Co., 330 E. Morrison St., Portland.

PENNSYLVANIA

Gash-Stull Co., Chester.

Barnard Tractor & Equipment Co., Inc., 825 Paxton St., Harrisburg.

Bowen Machinery Co., 1126 N. Delaware Ave., Philadelphia.

De Huff & Hopkins, 261 N. Broad St., Philadelphia.

Edelen & Boyer Co. Office and Warehouse: 236 N. 23rd St., Philadelphia.

HARRY J. FERGUSON

Complete Labor-Saving Material-Handling Equipment

626 Race St. **Philadelphia, Pa.**

Representing

SPROUT, WALDRON & CO., INC.—Material handling Equip., Elevating & Conveying Machy., Bulk Cement Handling Equip.

W. A. JONES FOUNDRY & MACHINE CO. — Spur - Herringbone and Worm Speed Reducer

MOLINE MALLEABLE IRON CO.—Malleable Iron Chain and Sprockets

MAERKY MACHINE WKS.

632 Race St. **Philadelphia, Pa.**

Representing

CLIMAX ENGINEERING CO., Sales Service and Parts

TWIN DISC CLUTCH CO., Sales Service and Parts

Service Any Make Gasoline Engine

Giles & Ransome, 17th St. and Sedgley Ave., Philadelphia.

Howard W. Read Corp., 800 N. Delaware Ave., Philadelphia.

Reeves-McCormick, Inc., 5317 N. 2nd St., Philadelphia.

Service Supply Corporation, 20th and Venango Sts., Philadelphia.

J. Jacob Shannon & Co., 1744 Market St., Philadelphia.

Allegheny Equipment Corporation, 1218 Grant Bldg., Pittsburgh.

Brinken Supply Co., 905 Clark Bldg., Pittsburgh.

Beckwith Machinery Co., 6550 Hamilton Ave., East Liberty, Pittsburgh.

C. H. Arnold Company, Inc., 726-730 Park Bldg., Pittsburgh.

A. H. Krigger & Co., 4 E. Carson St., Pittsburgh.

Martin J. O'Brien Co., Inc., 512 Columbia Bldg., Pittsburgh.

W. J. Doorley, Scottdale.

Ensminger & Company, 75-77 Hazle St., Wilkes-Barre.

Powell-Davies Tractor & Equipment Co., Inc., 152 Horton St., Wilkes-Barre.

SOUTH CAROLINA

Carolina Contractors Equipment & Supply Co., P. O. Box 576, Columbia.

Gibbes Machinery Co., Columbia.

Jeff Hunt Roach Machinery Co., Columbia.

SOUTH DAKOTA

Western Material Co., Sioux Falls, Huron, Rapid City, Aberdeen.

TENNESSEE

Nixon-Hasselle Co., Chattanooga.

Choctaw Culvert & Machinery Co., Second and Butler Sts., Memphis.

Nashville Tractor & Equipment Co., 322 Fifth Ave. S., Nashville.

Wilson-Weesner-Wilkinson Co., Nashville.

TEXAS

Browning-Ferris Machinery Co., 205 Exposition Ave., Dallas; Texas at Rice St., Houston.

Clark & Burrows, Inc., 3915 Main St., Dallas.

F. W. Gartner Company, 1010 Milby St., Houston.

Alamo Iron Works, 130 Santa Clara, San Antonio.

UTAH

The C. H. Jones Company, 134-140 Pierpont Ave., Salt Lake City.

VIRGINIA

Graham B. Bright, 1106 Electric Bldg., Richmond.

Earnest Bros., Inc., 14 N. Seventh St., Richmond.

Phillips Machinery Co., 900 E. Cary St., Richmond.

Jos. S. Potts, Jr. Company, Travelers Bldg., Richmond.

Southern Machinery & Supply Co., Roanoke.

WASHINGTON

Pacific Hoist & Derrick Co., 3200 Fourth, So. Seattle.

Construction Equipment Co., 1118-1124 Ide Ave., Spokane.

Hofius-Ferris Equipment Co., 728-802 Mallon Ave., Spokane.

GEIJSBEEK ENGINEERING CO.

Arctic Building **Seattle, Wash.**

Representing

HANSON Excavators
FATE-ROOT-HEATH Crushers
EAGLE Sand and Gravel Plants
STEDMAN Grinding Mills
NORTH AMERICAN REFRACTORIES CO.—Fire Brick

Pumps, Compressors, Drilling Tools, Contractors' Scientific Instruments

WEST VIRGINIA

Bluefield Supply Co., Bluefield.

General Equipment Co., Inc., 414 N. Fourth St., Clarksburg.

West Virginia Mine Supply Co., Clarksburg.

Bailey-Treen Machinery Co., 20th St. and B. & O. R. R., Huntington.

WISCONSIN

T. W. Meiklejohn Co., 520 N. Main St., Fond du Lac.

Boehck Equipment Co., 2404 W. Clybourn St., Milwaukee.

Cunningham-Ortmayer Co., 429 W. Michigan St., Milwaukee.

Drott Tractor Co., Inc., 3841 Wisconsin Ave., Milwaukee.

Engineers & Contractors Supply Co., West Allis.

Hunter Tractor & Machinery Co., 327 S. 16th St., Milwaukee; 627 E. Mifflin St., Madison.

W. A. Nelson Equipment Co., 534 N. 25th St., Milwaukee.

WYOMING

Robert T. Twedt Co., Inc., 15th St. and Pioneer Ave., Cheyenne.

CANADA

Ferguson Supply Co., Ltd., Calgary, Alta.

Brown, Fraser & Co., Ltd., Vancouver, B. C.

Kipp-Kelly, Ltd., 68 Higgins Ave., Winnipeg, Man.

London Concrete Machinery Co., Ltd., London, Ont.

Canadian Equipment Co., Ltd. .Consolidated Sales and Shop Offices: Bois Franc Road, St. Laurent, Montreal, P. Q.

General Construction Material Co., Ltd., 1194 Stanley St., Montreal, P. Q.

Hopkins-Osborn, Ltd., Successors to F. H. Hopkins & Co., Ltd., Dominion Square Bldg., Montreal, and Clare Osborn, Ltd., 159 Bay St., Toronto.

Just Equipment & Supply Co., Ltd., 173 Colborne St., Montreal, Que.

The Albert Olson Co., Ltd., 1148-50 Osler St., Regina, Sask.

ADVERTISERS' SECTION - - - -

ADVERTISERS' INDEX

Adams Company, J. D. 36-37-38-39
Allis-Chalmers Tractor Division 40-41
American Steel & Wire Company 42-43
Atlantic Refining Company, The 45
Austin-Western Road Machinery Co., The 46-47-48-49-50-51-52-53-54-55
Barrett Company, The 56-57
Blaw-Knox Company 58-59
Bucyrus-Erie Company 60
Burch Corporation, The 61
Calcium Chloride Association 62-63
Carey Company, The Philip 64
C. H. & E. Manufacturing Co., Inc. 65
Chicago Tubing & Braiding Co. 66
Cleaver-Brooks Co. 67
Cleveland Tractor Company, The 68-69
Columbia Alkali Corporation, The 62-63
Continental Roll & Steel Foundry Company 70
Curtis Pneumatic Machinery Company 71
Day Pulverizer Co., Inc. 72
Dow Chemical Company, The 62-63
Eagle-Picher Lead Company, The 73
Etnyre & Company, E. D. 74
Fairbanks, Morse & Co. 75
Flexible Road Joint Machine Company 76
Galion Iron Works & Mfg. Co., The 77-78
Gillette Publishing Company 65-67-76-79-88-100-115-122
Good Roads Machinery Corp. 79
Grasselli Chemical Company, The 80
Harnischfeger Corporation 81
Hauck Manufacturing Company 82
Heltzel Steel Form and Iron Company 83
Hercules Motors Corporation 84
Hercules Powder Company 85
Highway Steel Products Company 86
Honhorst Co., The Jos. 87
Industrial Brownhoist Corp. 88
Ingersoll-Rand 89
International Harvester Company 90-91-92-93
Jahn Company, C. R. 94
Johns-Manville 95
Kalman Steel Corporation 96
Leschen & Sons Rope Company, A. 97
Link-Belt Company 98-99
Macasphalt Corporation of America 100
Metal Forms Corporation 101-102
Mexican Petroleum Corporation 103
Michigan Alkali Company 62-63
National Carbide Sales Corporation 104
National Paving Brick Association ..... -105
Norma-Hoffmann Bearings Corporation 106
Page Steel and Wire Company 107
Portland Cement Association 108
Riddell Company, W. A. 109
Roads and Streets 44-136
Robeson Process Company 110
Sauerman Bros., Inc. 111
Servicised Products Corporation 112-113-114
Smith Company, The T. L. 116
Solvay Sales Corporation 62-63
Southern Wood Preserving Co. 117
Standard Oil Company (Indiana) 118-119
Standard Oil Co. of New York, Inc. 120-121
Sullivan Machinery Company 123
Texas Company, The 124-125
Timken Roller Bearing Company, The 126
Toledo Pressed Steel Co., The 127
Toncan Culvert Manufacturers' Association 128-129
Toro Manufacturing Co. 130
Truscon Steel Company 131
Tuthill Highway Guard 132
United States Pipe and Foundry Co. 133
Universal Crusher Company 134
Zaremba Snow Rooters 135

J. D. ADAMS COMPANY

Home Office and Factory—Indianapolis, Ind.

Branches: Minneapolis, Kansas City, Omaha, St. Louis, Dallas, Memphis, Atlanta, Spokane, and San Francisco
Representatives and Distributors in All States.

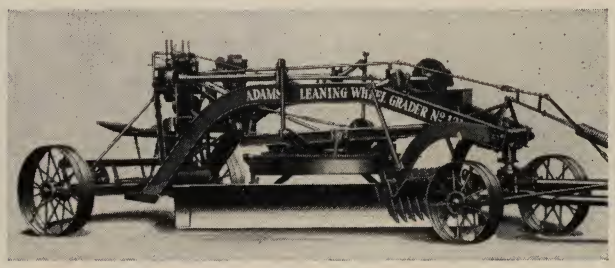
Products: Adams Leaning Wheel Graders, Scarifier-Graders, Motor Graders, Grader Blades for any make of Grader, Road Maintainers, Road Drags, Elevating Graders, Dump Wagons, Retread Pavers and Mixers, Wheeled Scrapers, Drag Scrapers, Fresnos, Road and Rooter Plows, etc.

Sales Service: Adams Equipment is sold and serviced throughout the United States and in most foreign countries by direct factory representatives or by distributors.

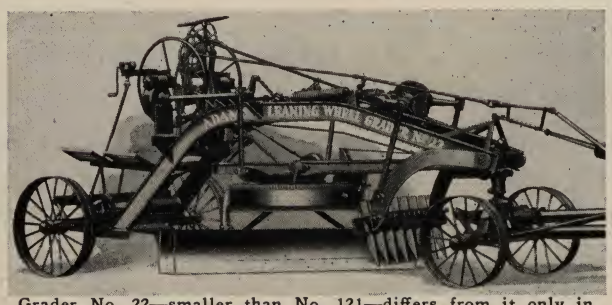
J. D. Adams, Limited, with factory at Paris, Ontario, has direct factory representatives or distributors throughout the Dominion. A request addressed to Indianapolis or our nearest branch office, will place an Adams representative at your service, without obligation, of course.

Adams are the original leaning wheel graders and are backed by forty-nine years of leaning wheel grader manufacturing experience. Five "high lift" machines with a wide range of blade adjustments are now available for those wishing this type of grader.

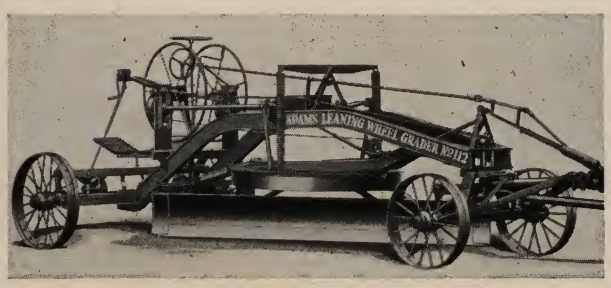
Outstanding features of Adams Leaning Wheel Graders are: machine cut and enclosed gears on all models, machine finished bearings and ball and socket connections throughout the blade control, well balanced design, high quality materials and workmanship, and long life. All models are equipped with roller bearing wheels.



Grader No. 121—a powerful scarifier-grader with a wide range of blade adjustments



Grader No. 22—smaller than No. 121—differs from it only in size and capacity



Grader No. 112—has wide range of blade adjustments for steep bank cutting, etc.

Adams Graders Furnished as Follows:

Grader No. 121: A powerful, heavy-duty combination scarifier-grader with extraordinary range of blade adjustments. Blade may be swung outward to either side to cut steep slopes. May also be extended far outside line of wheels for shoulder finishing, etc.

No. 121 is furnished with 10, 12, or 14 foot blade, with or without scarifier and with power or hand-operated controls. For tractors of 50 drawbar h.p. or more. Approximate weight without scarifier 10,980 lbs. For scarifier, add 1,620 lbs.

A shoulder finisher can be furnished for this machine which finishes shoulders to specifications up to 11 feet in width. This attachment is assembled on the right end of the moldboard and finishes the berm and ditch slope without getting the grader off the pavement.

Grader No. 22: An all-purpose combination scarifier-grader of the same design and construction as the No. 121—differs from it only in size and capacity. Also features a wide range of blade adjustments for steep bank cutting, shoulder finishing, etc. Furnished with 8, 9, or 10 foot blade, and with or without scarifier, as shown at left. For tractors of 30 to 50 drawbar h.p.

Approximate weight without scarifier 7,100 lbs. For scarifier, add 1,070 lbs.

A shoulder finisher similar to that for Grader No. 121 is available for this machine, for finishing shoulders up to 8 feet in width.

Grader No. 112: A new 'high-lift" grader with 12 ft. blade. Makes bank cuts as steep as 73 degrees (see illustration next page), and reaches 6½ ft. outside line of wheels for berm finishing—9½ ft. with moldboard extension. Power recommended, 40 to 60 drawbar h.p. Weight approximately, 7,750 lbs.

Continued on Next Page

Grader No. 83: A new 8 ft. blade "high lift" machine for steep bank cutting, etc., which can be used with the smaller tractors. Cuts 65 degree or steeper slopes with ease. For tractors of 20 to 40 drawbar h.p. May be fitted with scarifier. weight approximately 5,500 lbs.

Grader No. 72: A 7 ft. blade machine of the "high-lift" type. Recommended for tractors of 20 to 25 drawbar h.p. or can be furnished with wood tongue for use with 6 or 8 horses. A splendid grader for moderate ditching; with blade extensions, which lengthen blade to 11 ft., also serves well as a surface maintenance machine. Very suitable for the building and maintenance of township and town roads and streets. Weight with steerable tongue approximately 3,430 lbs.

Grader No. 31: A sturdy machine with a special appeal for those desiring a comparatively light scarifier-grader. Capable of splendid ditch work, and independently controlled scarifier makes it a very good all-round maintenance machine. Has 7 foot blade, and may be used with six horses or tractors of 12 to 25 drawbar h.p. Weight with 6 horse hitch, approximately 2,700 lbs.; with steerable tongue approximately 2,800 lbs. For machine with scarifier add 730 lbs.

Grader No. 21: A 7 ft. blade machine similar in design to grader No. 11 illustrated to the right. Recommended for tractors of 10 to 18 drawbar h.p. or for use with 4 or 6 horses. Best suited to the conditioning and maintenance of town streets. Weight, with steerable tongue for use with tractor, approximately 2,400 lbs.

Grader No. 11: Comes with 6½ or 8 foot blade, for light ditching or maintenance. Used as one-man two-horse machine, or two-man four-horse outfit. Also furnished with steerable tongue for tractors of 10 to 15 drawbar h.p. Weight with 2 horse hitch, approximately 1,795 lbs. Weight with steerable tongue, approximately 2,050 lbs.

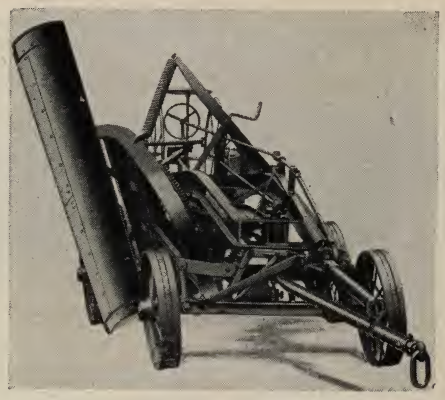
Useful Accessories for Adams Graders:

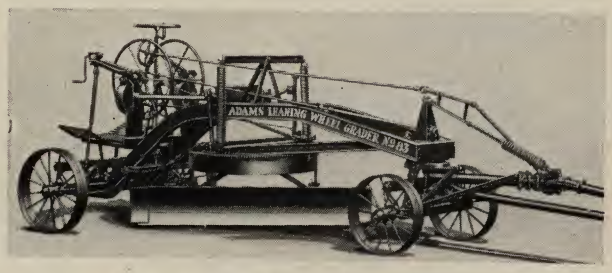
Backslopers: Can be furnished for all sizes of Adams Graders. Cut perfect "V" type or flat-bottom ditches. Easily put on and taken off of machines.

Moldboard or Blade Extensions: Used to lengthen blade for maintenance, casting dirt, finishing berms, etc. Bolt on front side of any Adams blade through holes already in moldboard. Increase blade length 3 ft. to 6 ft. according to size of grader.

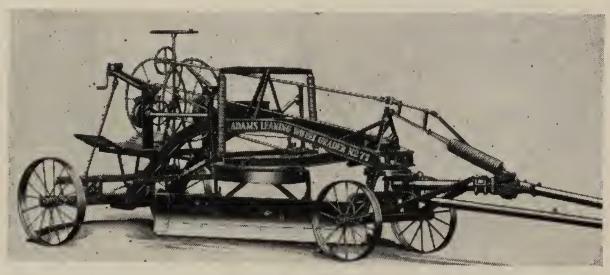
Scarifier Attachments: Scarifiers for graders Nos. 121, 22, 83, and 31, are mounted at front of machine and are independently controlled. Attachments for graders Nos. 112 and 72 are put on the semi-circle by temporarily removing the moldboard. Attachments for graders Nos. 21 and 11 are fastened to the blade circle in front of the moldboard.

Steep bank cutting position obtained with Adams "high lift" graders

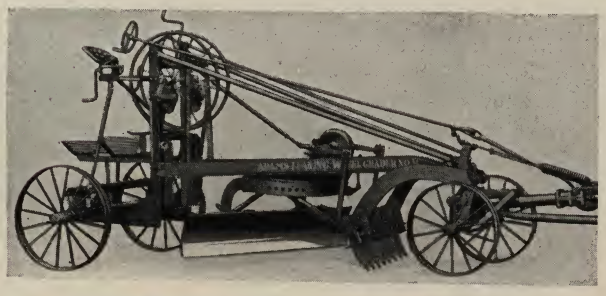




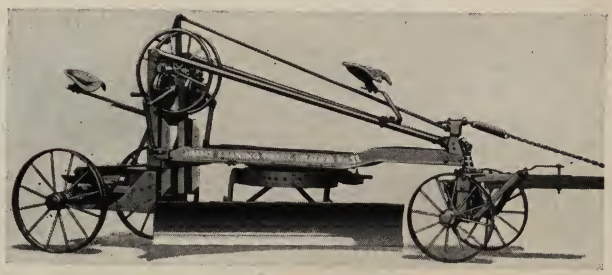
Grader No. 83—"High Lift" Machine—8-foot blade



Grader No. 72—"High-Lift" Machine—7-foot blade

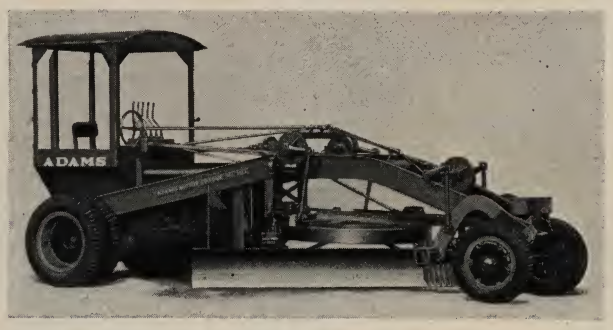


Grader No. 31—sturdy combination scarifier-grader with 7-foot blade

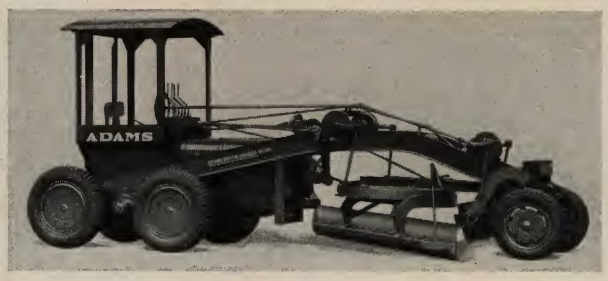


Grader No. 11—with 6½- or 8-foot blade

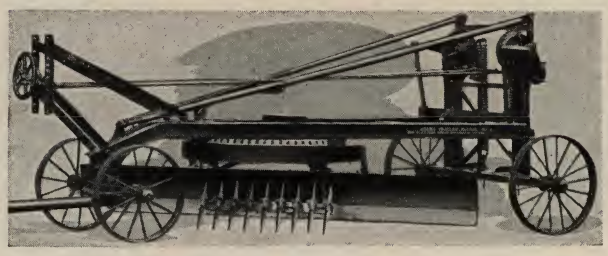
Continued on Next Page



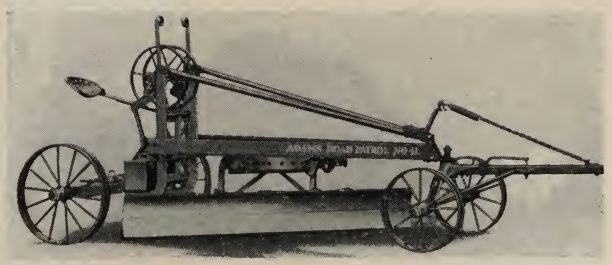
Motor Grader No. 301 with Powered Operated Controls
All Adams Motor Graders are similar in design



Equipped with Adams Tandem Drive on rear. Furnished with 4 or 8 drive wheels (four illustrated)



Trailer Patrol No. 9



Road Patrol for 2, 3 or 4 Horses

Adams Motor Graders: The strongest, most durable, most rigid, and smoothest cutting motor graders built. Strongest and most durable because all-welded construction and machine-finished throughout; most rigid and smooth cutting because of Adams distinctive frame design and complete absence of lost motion throughout the machine. Frame beams are large steel channels cross braced by four steel tubular cross members welded in place. The Adams frame is a single, solid all welded unit, which does not yield to twist. Drawbars and blade circles are also completely welded; there are no rivets to loosen and cause vibration. All gears are machine-cut, enclosed and run in oil. All bearings and connections are machine-finished and adjustable for wear.

Adams Motor Graders are available in two sizes of McCormick-Deering Tractors and two sizes of Case Tractors as listed below. All models are furnished with 10, 12, 14, or 16 ft. blades and with or without independently controlled scarifier. All models are also furnished with dual tires rear or Adams Tandem Drive with four or eight wheels.

Adams Motor Grader No. 401: Powered by McCormick-Deering Model 30 Tractor which develops 45 engine h.p.; has power operated controls. Approximate weight with 12 ft. blade and scarifier (two wheel drive), 17,435 lbs. Same machine can be had with hand controls—known as Model 40.

Adams Motor Grader No. 301: Powered by McCormick-Deering Model I-30 Tractor which develops 39 engine h.p.; has power operated controls. Approximate weight with 12 ft. blade and scarifier (two wheel drive), 12,775 lbs. Same machine can be furnished with hand controls—known as Model 30.

Adams Motor Grader No. 151: Powered by Case LI Tractor which develops 50 engine h.p.; has power-operated controls. Approximate weight, with 12 ft. blade and scarifier, 15,935 lbs. Same machine can be furnished with hand controls—known as Model 15.

Adams Motor Grader No. 171: Powered by Case Model CI Tractor which develops 31 engine h.p.; has power-operated controls. Approximate weight, 13,450 lbs. Also furnished with hand controls—known as Model 17.

Trailer Patrol No. 9: A wonderfully strong and smooth cutting road and street maintainer which can be readily hitched to any tractor or truck. Machine is illustrated with tractor hitch at left for operation by tractor operator. Control wheels, spring mounted platform, and comfortable seat are furnished for the rear of the machine when to be used with trucks. Available with 10, 12, 14 or 16 ft. blade and with or without scarifier. Weight with tractor hitch, without scarifier, approximately 4,375 lbs. For scarifier, add 250 lbs.

Adams Road Patrol: A high-class road and street maintainer furnished with 8 or 10 ft. blade for use with 2, 3, or 4 horses. Has strong, rigid triangular design which makes it unequalled for rigidity and smooth cutting. Has machine-finished ball and socket lift links and moldboard connections —no lost motion to cause blade chattering. All riveted construction—built for long life and low upkeep. Approximate weight with 8 ft. blade as illustrated 1,400 lbs.

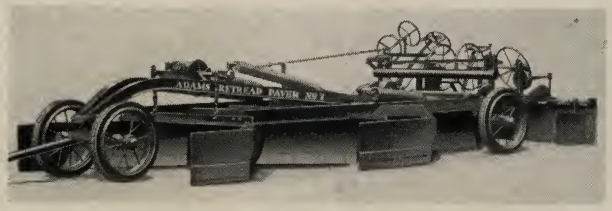
Adams "Multiple Blade" Road Maintainer



Can be hitched to any tractor and is operated by tractor operator. When worked with McCormick-Deering Tractors (as illustrated) can be power operated through Adams Power Control Unit put on rear of tractor. For use with other tractors, a single-wheel hand control mounted on front of machine is provided; control is adjustable to be within easy reach of operator. This maintainer has 40 ft. of blades which work the road surface four times in one trip; it has no equal for removing "chatter bumps" in gravel or stone roads. Can be fitted with scarifier. Approximate weight as illustrated, 4,620 lbs.

Continued on Next Page

Adams Retread Paver: For "mixed-in-place" construction and retread work. Mixes 3 to 3½ in. of stone, gravel, etc., with bituminous binder, and distributes and levels the mixed material to specifications in a smooth continuous ribbon ready for compaction. There is no other machine on the market that performs this work so quickly, satisfactorily and economically. Mixes material three times in one trip. Pulled by tractors of 60 drawbar h.p. or more Weight, 8,245 lbs.



Retread Paver

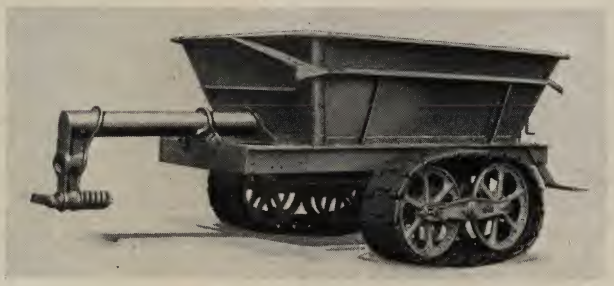
Adams Elevating Graders Nos. 10 and 11: The last word in elevating grader design—featuring shaft and gear driven carriers, roller and ball bearing equipment throughout, and exceptionally rigid carriers unequalled for ease of running and reduction of belt costs. The No. 10 has a 42 in. carrier 16 or 19 ft. long which is driven by auxiliary engine or power take-off from tractor. Weight, with power take-off, approximately 12,955 lbs. With auxiliary power unit, approximately 14,360 lbs.

No. 11 is a new machine, featuring distinctive frame and front axle design, a new plow beam, 48 in. carrier, and power operated controls for raising and lowering the upper carrier, center of carrier, lower carrier, and plow. Available with 25, 22, 19 foot and shorter carriers, and with auxiliary engine drive or power take-off. Weight with power take-off, approximately 14,415 lbs.; with McCormick-Deering power unit, approximately 15,515 lbs.



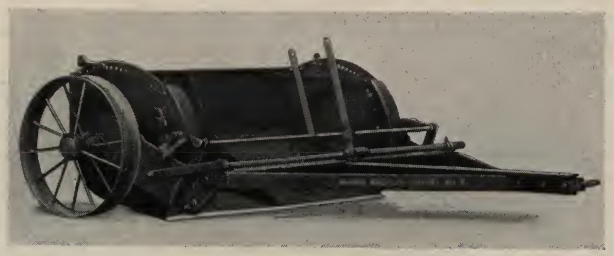
Elevating Grader No. 11—Power Operated

Adams Bottom-Dump and Three-Way-Dump Trailers: Bottom-Dump Trailers, as illustrated, are available in two sizes—6-6½ yd. and 7½-8½ yd. capacities. They are very sturdily built, the doors are easily tripped and rewound and bodies are mounted on heavy-duty Trackson Crawler Wheels of 15 and 20-ton capacities. All models equipped with removable side extensions to adapt trailers to use with elevating graders. 6-6½ yd. model weighs approx. 10,000 lbs.; 7½-8½ yd. model weighs approx. 13,500 lbs. Adams Three-Way-Dump Trailers dump to the rear or either side and are hydraulically controlled. They are furnished in 5-7 yd. and 7-10 yd. sizes mounted on Trackson Crawler Wheels of 15 and 20-ton capacities. 5-7 yd. model weighs approx. 12,200 lbs.; 7-10 yd. model weighs approx. 15,700 lbs.



Bottom-Dump Trailer

Rotary Scrapers: Available in wheeled or drag types Wheeled type scrapers are very popular, because the wheels carry most of the load, making lighter draft; also wheels make scraper easy to move about on the job. Wheeled type scrapers come in 5 to 8 foot bowl lengths ranging from 31 to 90 cubic foot capacities. Drag type scrapers come in 4 to 8 foot bowl lengths, ranging from 12 to 70 cubic foot capacities.



Wheeled Rotary Scraper

Rooter and Road Plows: Rooter plow has cast steel beam, strongly braced steel handles, and double reversible point of special tool steel. Road plows have beams of best white oak, heavily ironed. Reversible cutters, moldboards and shares are of best grade plow steel. Weights: Rooter Plow approximately 395 lbs. Road Plows, from 135 to 320 lbs.



Rooter Plow



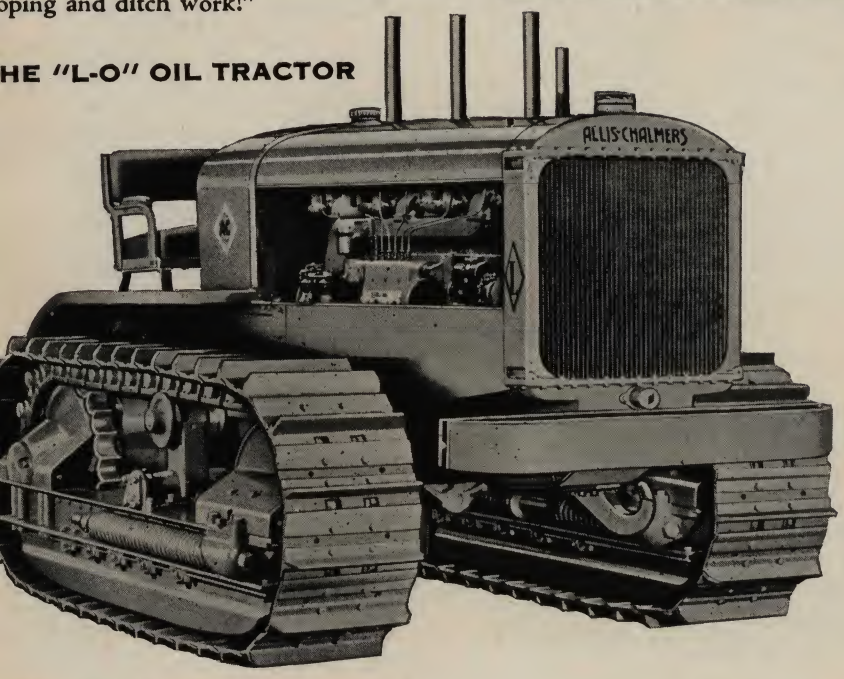
Adams Grader Blades for Any Make of Grader Give You the "Most Miles per Dollar"

'Yes we have good roads in



Before I was commissioner I operated a
2-foot hand controlled grader for the
unty. Had to stand up all day and fight
e blade. Was too tired to read the paper
hen I got home. My wife said I was kill-
g myself. The A-C No. 14 power con-
olled grader does work we never expected
do, and boy, how the operators like it!
nd the Model "L" tractor is the finest
actor we ever had. This combination
n't be beat for heavy road-building, bank
oping and ditch work!"

HE "L-O" OIL TRACTOR



ESSELMAN PATENT



Spark Firing Atomized Fuel Oil in Oil Engine

"And if you want oil burning tractors, Allis-Chalmers have just introduced an entirely new principle in oil burning engines. They use a Diesel fuel pump to inject the measured charge of fuel oil into the combustion chamber and ignite it with a spark. Instead of depending upon compression for ignition they use the time tried magneto. This engine will operate with less maintenance cost because the internal pressures are less than one-third those used in the compression type. I believe Allis-Chalmers are right in saying, 'The new oil tractors will do more work at less cost than any other tractors'."

"Yes, and the nice part of it is you can get these A-C oil burning tractors in two models — the "K-O," which develops 48 drawbar horsepower and weighs approximately 11,200 pounds — and the Model "L-O" which develops 76 drawbar horsepower and weighs approximately 23,000 pounds."

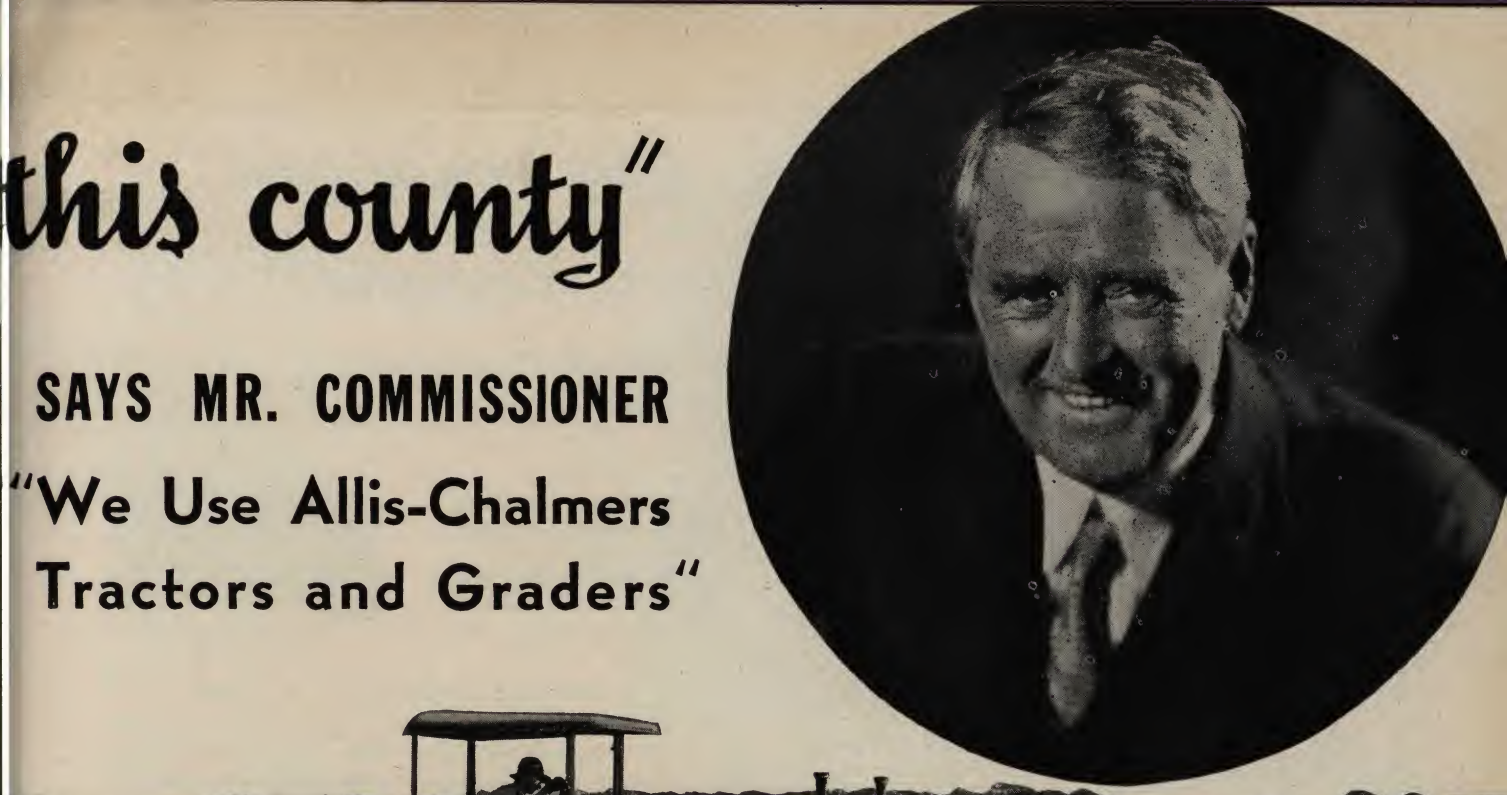
ALLIS-C

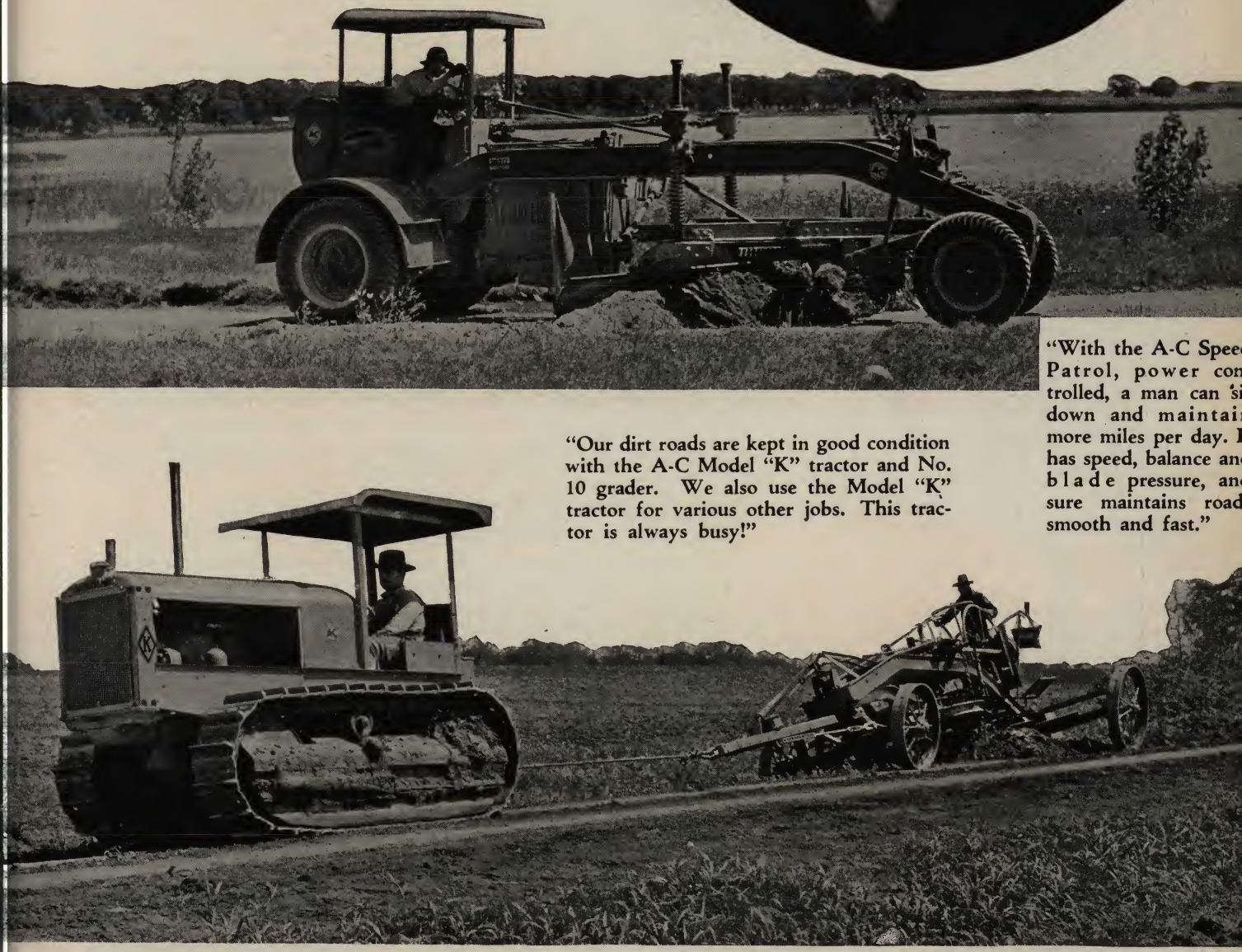
TRACTOR DIVISION

this county"

SAYS MR. COMMISSIONER

"We Use Allis-Chalmers Tractors and Graders"





"Our dirt roads are kept in good condition with the A-C Model "K" tractor and No. 10 grader. We also use the Model "K" tractor for various other jobs. This tractor is always busy!"

"With the A-C Spee Patrol, power con trolled, a man can 'si down and maintai more miles per day. I has speed, balance an blade pressure, an sure maintains road smooth and fast."

HALMERS

—MILWAUKEE, U. S. A.

"They also make Power Controlled Graders; Hand Controlled Graders; Speed Patrol Graders; Track-Type Tractors; Elevating Graders; Power Units, Models 40, 50, 60, 90, H.P.; Wheel Type Tractors; Track-Type Wagons and Wagon Tracks."

AMERICAN STEEL & WIRE COMPANY

SUBSIDIARY OF UNITED STATES STEEL CORPORATION

Chicago—208 S. La Salle St. New York—Empire State Bldg.

Wire Reinforcing Fabrics for Concrete Pavements

Products: Triangle Mesh and Electric Weld Wire Fabrics.

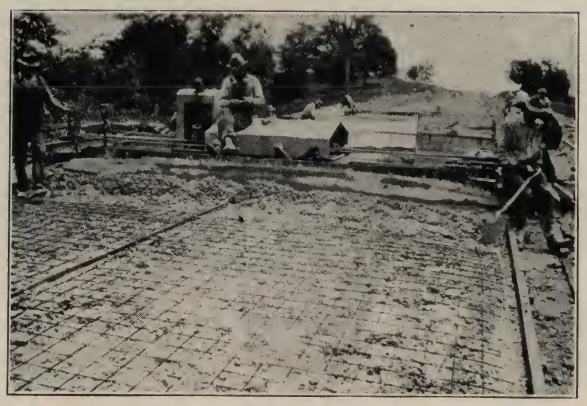
Concrete Pavement and Bases

No State that has once specified wire fabric reinforcement in their pavement design has ever discontinued its use. Experience, test roads, National Surveys of existing pavements, with and without reinforcement all conclusively prove that wire fabric reinforcement increased the life of all concrete pavements and bases. The data available all agree that wire fabric has solved the cracking problems of concrete pavements and concrete bases: thereby, increasing their life and utility.

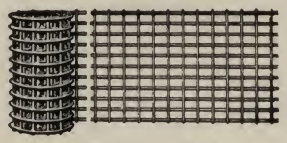
Advantages of Cold Drawn Wire Fabric

One of the primary functions of wire fabric in concrete pavements and concrete bases is to hold cracks together and thereby increase its load carrying capacity. Cold drawn wire fabric is particularly efficient in preventing crack opening due to its small members of high elastic limit steel closely spaced.

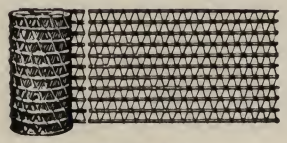
Cold drawn wire as used in wire fabric has no definite yield point at or near its elastic limit. A hot rolled bar which the manufacturer of cold drawn wire fabric must first use to make the finished wire has a definite yield point at approximately half its ultimate strength. The additional work done on the hot rolled bar by the wire fabric manufacturer, therefore, refines the structure of the steel to where it is safe to use a much higher working stress on the wire. A cold drawn wire may be stressed almost to the point of its ultimate strength without an appreciable amount of sudden elongation such as always occurs on the original hot rolled bar at a stress of about one-half its ultimate strength. If the original hot rolled bar was used in the concrete before it is drawn cold into wire it could not prevent an appreciable crack opening beyond the yield point of the bar. If the ultimate strength of the bar was 70,000 pounds it could not function beyond a stress of 35,000 to 40,000 pounds per square inch. However, after working into wire to an ultimate strength between 70,000 to 80,000 pounds per square inch, wide crack openings will be prevented practically to the limit of the wires ultimate tensile strength.



Typical Road Scene Showing Wire Fabric Installed



Electric Weld



Triangle Mesh

Recommended Specifications for Roads

Roads: The reinforcement shall consist of a steel wire fabric manufactured from cold drawn wire, finished members of which shall develop an ultimate tensile strength of at least 70,000 pounds per square inch and which shall bend cold 180 degrees around a pin the diameter of which is equal to the diameter of the wire specimen without cracking on the outside of the bent portion.

All reinforcement shall be free from excessive rust, scale, paint or coating of any character which will tend to prevent proper bonding of the concrete.

The longitudinal wires of the fabric shall be spaced six (6) inches and shall be No. ... *gauge except ... *wires on each side of the sheet shall be No. ... *gauge. The transverse wires of the fabric shall be spaced ... *inches and shall be No. ... *gauge. The fabric shall weigh not less than ... *pounds per 100 square feet of fabric.

**Local conditions govern. For average conditions with a 20 foot road use No. 5 gauge longitudinal wires except four wires on each side of sheet shall be No. 0 gauge, and No. 5 gauge transverse wires spaced twelve (12) inches. Estimated weight 51 pounds per 100 square feet of fabric.*

Recommended Specifications for City Streets

City Streets: The reinforcement shall consist of a steel wire fabric manufactured from cold drawn wire, finished members of which shall develop an ultimate tensile strength of at least 70,000 pounds per square inch and which shall bend cold 180 degrees around a pin the diameter of which is equal to the diameter of the wire specimen without cracking on the outside of the bent portion. All reinforcement shall be free from excessive rust, scale, paint or coating of any character which will tend to prevent proper bonding of the concrete.

The longitudinal wires of the fabric shall be spaced not less than four (4) nor more than six (6) inches and shall have a sectional area of not less than ... *square inches of steel per foot of fabric. The transverse wires of the fabric shall be spaced not less than four (4) inches nor more than twelve (12) inches and shall have a sectional area of not less than . . . *square inches of steel per foot of fabric. The fabric shall weigh not less than . . . *pounds per 100 feet of fabric.

**Local conditions govern. For average conditions use 6-in. x 6-in.—No. 5 and No. 5 weight 49 pounds per 100 square feet or 6-in. x 6-in. No. 4 and No. 4, weight 58 pounds per 100 square feet.*



Send for our Handbook on Reinforced Roads & Streets

AMERICAN STEEL & WIRE COMPANY

SUBSIDIARY OF UNITED STATES STEEL CORPORATION

Perfected Guard Rail Strand American Wire Rope

SALES OFFICES

Chicago, 208 So. La Salle St.
Cleveland, Rockefeller Bldg.
Detroit, General Motors Bldg.
Cincinnati, Union Trust Bldg.
St. Paul, First National Bank Bldg.
Milwaukee, Bankers Bldg.
St. Louis, 506 Olive St.
Kansas City, 417 Grand Ave.
Oklahoma City, Ramsey Tower.
Birmingham, Brown-Marx Bldg.

New York, Empire State Bldg.
Boston, Statler Bldg.
Pittsburgh, Frick Bldg.
Philadelphia, Widener Bldg.
Atlanta, 696 Whitehall St. S. W.
Worcester, 94 Grove St.
Baltimore, First National Bank Bldg.
Buffalo, 670 Ellicott St.
Wilkes-Barre, Miners Bank Bldg.

Houston, Petroleum Bldg.
Memphis, Sterick Bldg.
Dallas, Praetorian Bldg.
Denver, First National Bank Bldg.
Salt Lake City, Walker Bank Bldg.
***Columbia Steel Company:**
***San Francisco**—Russ Bldg.
***Los Angeles**—2087 E. Slauson Ave.
***Portland**—2345 NW Nicolai St.
***Seattle**—4th Ave. So. and Connecticut St.

For Reinforced Fabric, See Pages 68-69

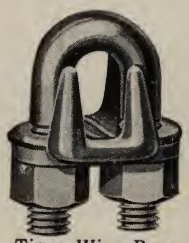
We manufacture many products used in highway construction. Some of these items are Wire Fabric Reinforcement—Wire Rope—Steel Posts for Highway Signs and Fences and Wire Rope Fittings such as Tiger Clips, Tiger Sockets and Galvanized Oval Thimbles.

Perfected Guard Rail Strand is made to conform to the specifications of the various State Highway Commissions.



Perfected Extra Galvanized Guard Rail Strand

Our Perfected Extra Galvanized Guard Rail Strand is Galvanized by our own Perfected Galvanizing Process, which means that each wire in the strand is covered with a non-peeling and non-cracking coating of galvanizing. This means longer life.



Tiger Wire Rope Clip Drop Forged, with the Yellow Base



6x19 Hemp Center Wire Rope

American Wire Rope for Road Building Equipment

Wire Rope used on road equipment must be of very high grade and in most cases possess high tensile strength. The following constructions and sizes are ordinarily used:

Boom Lines usually 6x19 Plow, Hemp or Wire Center.
Bucket Lines usually 6x19 Monitor Steel Silver Strand, Hemp or Wire Center.
Drag Lines usually 6x21 Monitor Steel Silver Strand, Hemp or Wire Center.

Our Engineers will gladly help to solve your wire rope problems. Please write us for catalogue.

STEEL POSTS

For Snow Fencing and Highway Signs

MADE IN VARIOUS WEIGHTS AND STYLES FOR ALL PURPOSES



AMERICAN
SNO GARD STEEL POSTS

SNOGARD POSTS are formed into a rounded back, flanged channel shaped post, equipped with riveted hooks to support snow fencing. Made in 4 weights.

BANNER TEE POSTS are 1⅜" in width. Furnished in one weight 1.325 pounds per foot, painted or galvanized.

IDEAL U POSTS are furnished with or without punched tongues for snow fencing, or punched holes for sign bolts. Made in 5 weights.

GIDERITE POSTS are similar in shape to SnoGard Posts. Furnished with punched holes for sign bolts. Made in 7 weights.

◆

All these posts are made from specially selected steel and are furnished in all standard weights and lengths, painted with a high grade steel paint—baked on, or hot galvanized. Write for catalogues and full details.



AMERICAN GIDE-RITE SIGN POSTS



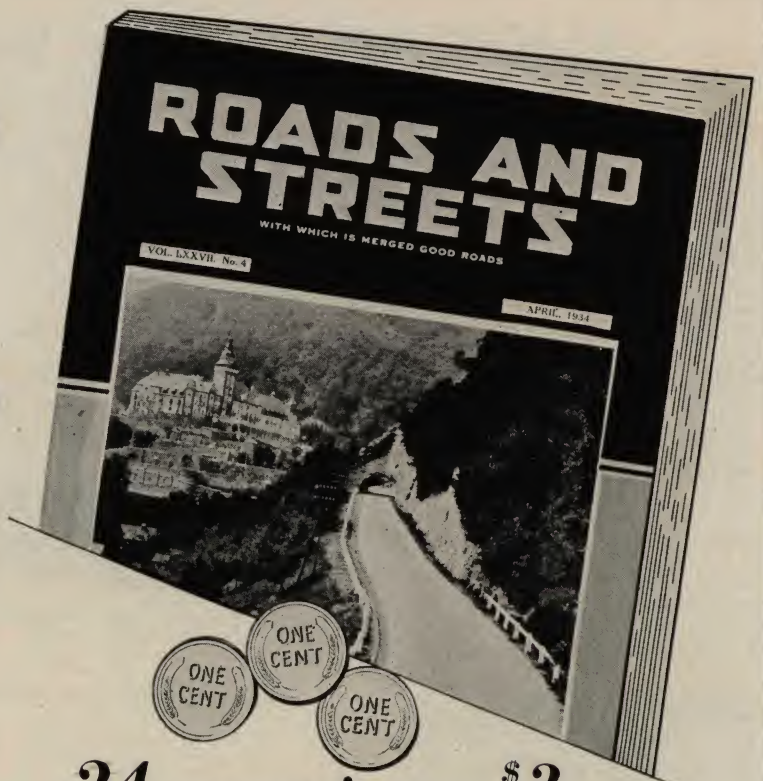
IDEAL-U STEEL POSTS

only 3 cents
A WEEK

Brings you—

ROADS AND STREETS

The Leading Magazine of The Roads and Streets Field



24 great issues $3

TIMES change, ideas change—it's up to you to keep in step and STEP UP—or step out. You don't know what is going to happen next month that might seriously effect your work. Neither do we — but this we both know. When important developments occur they are recorded authoritatively, accurately and promptly in ROADS AND STREETS.

Here is one magazine that keeps you up-to-date on all that is new in your field. Its editors and writers are all men with practical experience in road and street construction and engineering. They give you facts about new materials, new methods and new equipment that you can make use of in your work. And just one new idea from ROADS AND STREETS that you can use might be worth hundreds and even thousands of dollars to you.

No thinking man will want to be without the specialized information contained in each issue of ROADS AND STREETS—especially when the cost is only 3c a week—the price of your daily newspaper.

Don't Miss Another Issue—Subscribe Today!

All you need do to start ROADS AND STREETS coming your way is to pin your check for $3 (for two full years' subscription) to your letterhead and mail it to the address below. The current issue will be mailed to you at once.

OUR GUARANTEE If after reading the next three issues of ROADS AND STREETS you are not entirely satisfied, simply tell us so and the entire amount you paid will be refunded without question.

ROADS AND STREETS

A GILLETTE PUBLICATION

400 West Madison Street **CHICAGO, ILL.**

ATLANTIC ASPHALT



• ULTRA MODERN EQUIPMENT

ATLANTIC ASPHALTS AND ASPHALT PRODUCTS FOR COMPOUNDING AND INDUSTRIAL PURPOSES

ATLANTIC ASPHALTS FOR AIRPORT CONSTRUCTION SPECIALIZING IN MIXED-IN-PLACE AND BITUMINOUS MACADAM METHOD

ATLANTIC ASPHALTS AND ROAD OILS FOR ALL HIGHWAY PURPOSES

COMPANY OWNED AND OPERATED ASPHALT DISTRIBUTORS

ENGINEERING ADVICE FOR ALL TYPES OF CONSTRUCTION

THE ATLANTIC REFINING COMPANY

PHILADELPHIA, PA.

Asphalt Refineries located at Philadelphia, Pa., and Brunswick, Ga.

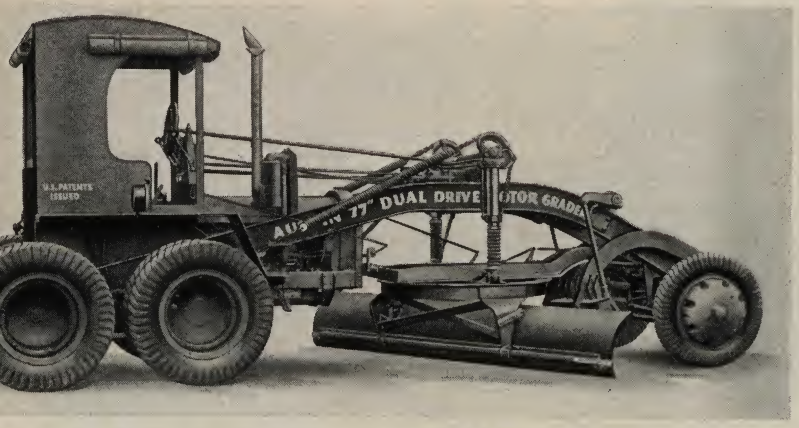
THE AUSTIN-WESTERN ROAD MACHINERY CO.

Home Office: 400 N. Michigan Ave., Chicago

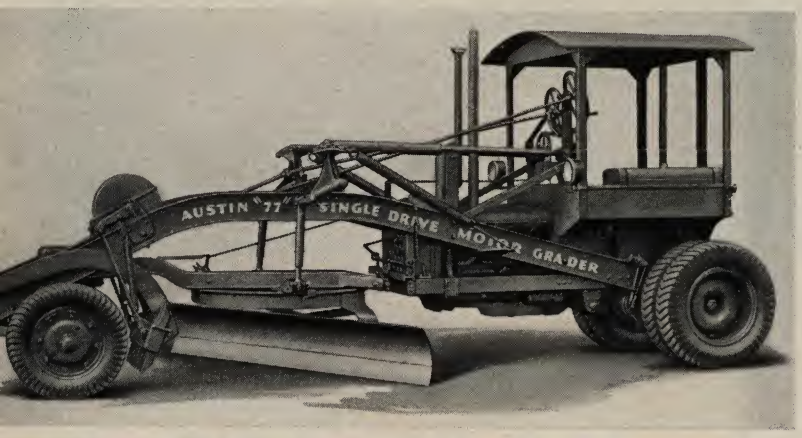
BRANCH OFFICES AND WAREHOUSES IN PRINCIPAL CITIES

AUSTIN NO. 77 MOTOR GRADERS

The leader of the Austin motor grader line is the 77 Sr. Dual Drive, which has set entirely new standards of motor grader performance, and has proved itself capable of handling not only maintenance but also many kinds of grading and ditching which are entirely beyond the ability of ordinary motor graders. The Dual Drive is probably its most outstanding feature, but the machine abounds in features of scarcely less importance, including the 6-speed transmission; the extra wide front axle (with either straight or leaning wheels), which is largely responsible for the machine's ability to grade as well as maintain; the large diameter circle with its welded blade arms, and the many precision features which eliminate lost motion and guarantee long life. Both hand and hydraulic controls are available; the latter, with its ease and speed of operation and accuracy of adjustment, is wanted in the majority of cases. The wide range of equipment with which the machine is regularly equipped, or can be equipped on special order, is listed in the specifications below.



Austin No. 77 Sr. Dual Drive Hydraulic Control Motor Grader with scarifier attachment.



Austin No. 77 Sr. Single Drive Hand Control Motor Grader with scarifier attachment.

No. 77 Sr. Single Drive Motor Grader

Except for the drive itself, this model is practically identical with the No. 77 Sr. Dual Drive. It takes the same regular and special equipment, and will be found entirely satisfactory in cases where the maximum power and traction of the Dual Drive are not required.

No. 77 Junior Dual and Single Drive Motor Graders

Where a smaller machine without the weight, power and super efficiency of the No. 77 Sr. is adequate, the No. 77 Junior will be found capable of doing all and more than other motor graders of its size and weight. The Junior is available in both Dual and Single Drive models, both of which have many of the features of the Senior.

COMPARATIVE SPECIFICATIONS FOR AUSTIN MOTOR GRADERS

MODEL	No. 77 Sr. Dual Drive Buda K-369	No. 77 Sr. Single Drive Buda K-325	No. 77 Junior Dual Drive I.H.C. I-30	No. 77 Junior Single Drive I.H.C. I-30
Weight, Approximately	16,500 lbs.	14,000 lbs.	14,100 lbs.	11,500 lbs.
Wheelbase	16'6"	18'¾"	17'3"	17'3"
Tread, Front	80"	80"	52"	52"
Tread, Rear-Outside	7'3"	6'3"	7'2"	6'5"
Engine	Buda K-369	Buda K-325	I.H.C. I-30	I.H.C. I-30
Number Cylinders	6, with removable sleeves	6, with removable sleeves	4, with removable sleeves	4, with removable sleeves
Bore and Stroke	4-1/16" x 4¾"	3-13/16" x 4¾"	4¼" x 5"	4¼" x 5"
Brake Horsepower	53	49	39	39
Governed Speed	1200 R.P.M.	1200 R.P.M.	1150 R.P.M.	1150 R.P.M.
Road Speeds	Six Forward: 1:39 to 13 M.P.H. Two Reverse	Six Forward: 1:39 to 13 M.P.H. Two Reverse	Four Forward: 2.5 to 10 M.P.H. One Reverse	Four Forward: 2.5 to 10 M.P.H. One Reverse
Blade, Standard	12' x ¾"	12' x ¾"	12' x ½"	12' x ½"
Frame	10" Channel 30 lb. per ft.	10" Channel 30 lb. per ft.	10" Channel 25 lb. per ft.	10" Channel 25 lb. per ft.
Rear Wheels	40" x 8" Dual Tires	40" x 8" Dual Tires	38" x 7" Dual Tires	38" x 7" Dual Tires
Front Wheels	32" x 6" Tires	32" x 6" Tires	32" x 6" Tires	32" x 6" Tires

AVAILABLE EQUIPMENT: Scarifiers—with 9 reversible teeth, 41" swath; with 13 reversible teeth, 48" swath; Various combinations of tires; Leaning front wheels with 36" x 6" tires; Snow Plows; Cabs; Hand Control instead of Power Control; Wheel Brakes; Drag Attachments; Electric Lights; Electric Starter; Gradometers; Oil-mix Blades; Diesel, Tractor, and 4-Cylinder Power Units.

NOTE: The right is reserved to change specifications without notice.

THE AUSTIN-WESTERN ROAD MACHINERY CO.

Home Office: 400 N. Michigan Ave., Chicago

BRANCH OFFICES AND WAREHOUSES IN PRINCIPAL CITIES

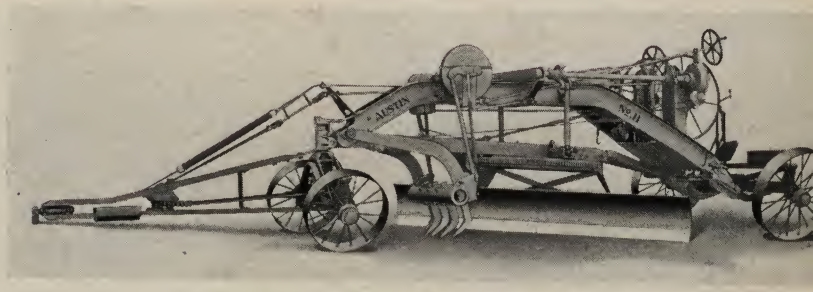
Austin Road Graders

The Austin road grader line for 1934 has been completed by the addition of the new No. 11, a model in the light 12-foot class, with weight and strength to handle all but the most difficult jobs. In each of the four Austin models, strength, capacity, durability, visibility, flexibility and adaptability are developed to the highest possible degree.

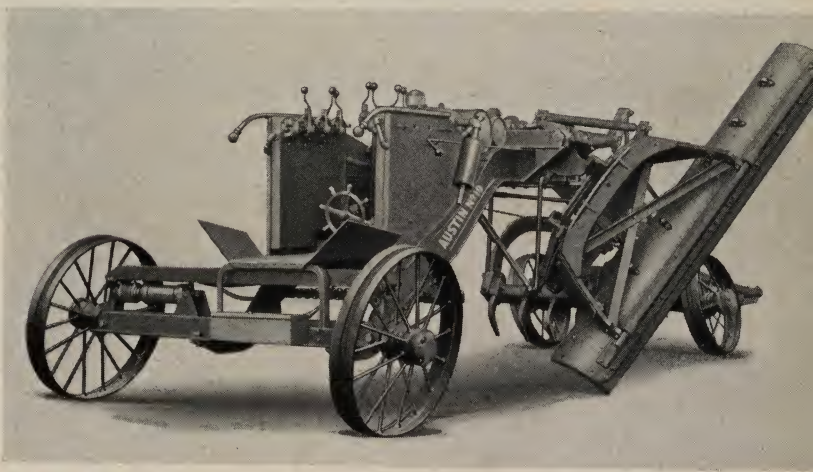
The hydraulic power control, with which the No. 12, No. 11 and No. 10 models may be equipped, provides the fastest, smoothest and most efficient means of operating the blade, leaning the wheels, shifting the frame on the rear axle, steering and operating the scarifier attachment. This ease of operation is especially noticeable when raising the blade to the high lift, or bank cutting, position. The hydraulic action is positive, and the operator is relieved of all strenuous muscular effort.

Special equipment includes various types of hand and hydraulically operated scarifier attachments, automatic wheel leaning on the hand control No. 12, No. 11 and No. 10 sizes, combination back slopers, shoulder finishing attachments, blade extensions, solid and pneumatic rubber tires, and canopy tops.

The Hydraulic Trailer Maintainer is a one-man outfit with the tractor operator in complete control of the grader at all times. While primarily designed for maintenance, it will also handle certain kinds of leveling and grading. A 12-foot blade and steel tired straight wheels are regular equipment. Blades of special lengths, leaning wheels, and solid or pneumatic rubber tires may be had, if wanted.



Austin No. 11 Hand Control Road Grader

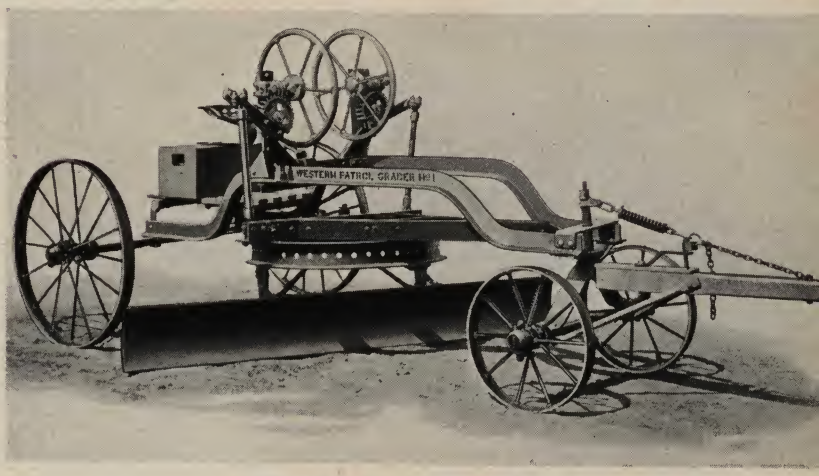


Austin No. 10 Hydraulic Control Road Grader with blade in high lift positio

Western Road Graders

The Western No. 35 is designed for light grading and maintenance behind medium-sized tractors. The No. 37 is a front control maintenance unit patterned after the No. 35 Grader.

The No. 22 is a leaning wheel grader which is popular for both maintenance, and light grading and finishing. The Little Western Grader has for years been the most popular model of its size and type. This is also true of the Western No. 1 Patrol Grader and its smaller companion, the No. 12. Both are famous for their "no lost motion" features.

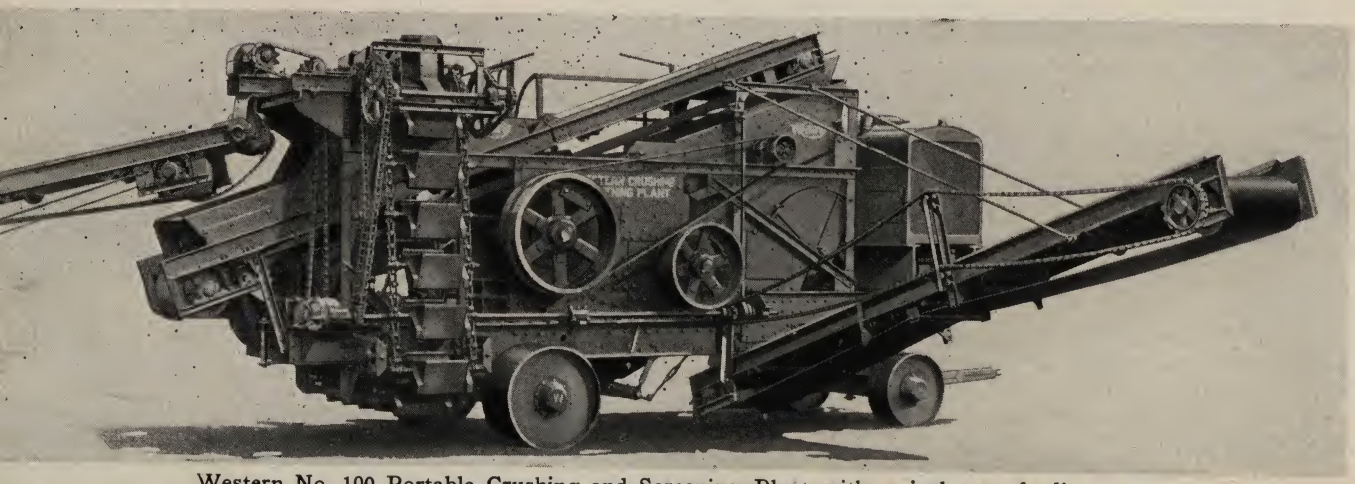


Western No. 1 Patrol Grader

COMPARATIVE SPECIFICATIONS FOR AUSTIN-WESTERN ROAD GRADERS

MODEL	Austin No. 12 Hand	Austin No. 12. Hydr.	Austin No. 11 Hand	Austin No. 11 Hydr.	Austin No. 10 Hand	Austin No. 10 Hydr.	Austin No. 8	Austin Hydr. Maint'r	West'rn No. 35	West'rn No. 22	West'rn No. 12	Western No. 1	West'rn No. 37	Little Western
Weight	11,500*	12,000*	9,400*	10,000*	7,245*	8,045*	5,460*	4,700*	3,758*	2,440*	1,330*	1,640*	3,458*	1,550*
Wt., with Scarifier	13,100*	13,600*	11,000*	11,600*	8,225*	9,025*	6,420*	5,560*	3,908*					
Blade, Length	12′	12′	12′	12′	10′	10′	8′	12′	8′	8′	8′	8′	12′	6′
Blade, Vert. Ht.	22⅜″	22⅜″	20″	20″	18″	18″	18″	18″	19″	12½″	13″	13″	17″	14½″
Blade, Thickness	¾″	¾″	⅝″	⅝″	⅝″	⅝″	½″	½″	½″	⅜″	⅜″	⅜″	½″	⅜″
Tread, Front	6′ 0″	6′ 0″	5′ 7 3/16″	5′ 7 3/16″	5′ 4″	5′ 4″	4′ 9″	4′ 9″	3′ 7¾″	3′ 6″	2′ 9″	3′ 2″	3′ 7¾″	3′ 2″
Tread, Rear	8′ 9″	8′ 9″	8′ 6″	8′ 6″	7′ 8″	7′ 8″	7′ 3″	7′ 3″	6′ 0″	5′ 4″	5′ 8″	6′ 0″	6′ 0″	6′ 0″
Wheelbase	18′ 9″	18′ 9″	17′ 6″	17′ 6″	15′ 7″	15′ 7″	13′ 6″	13′ 6″	12′ 0″	9′ 5½″	8′ 7″	9′ 0″	12′ 0″	8′ 0″
Frame, Size and Weight	12″, 30* Chan'l	12″, 30* Chan'l	10″, 25* Chan'l	10″, 25* Chan'l	9″, 20* Chan'l	9″, 20* Chan'l	7″,17¼* Chan'l	7″,17¼* Chan'l	"Z" Bar	3½″, T	2½″x3″ x 5/16″, T	3½″x3½″ x⅜″, T	"Z" Bar	3½″x3½″ x⅜″, T

* Indicates Lbs. Note:—The right is reserved to change specifications without notice.



Western No. 100 Portable Crushing and Screening Plant with swivel type feeding conveyor, and short discharge conveyor.

Crushing and Screening Plants

The Western line includes many sizes and styles of crushing and screening plants, ranging from the smallest unit to the magnificent, all anti-friction bearing No. 100 Plant, with its primary and secondary crushers; and the single crusher No. 90 and No. 80 Plants with their but slightly smaller capacities. Western Jaw Crushers are made in five sizes, all of which, with the exception of the new primary crusher No. 1838, with its 18-inch by 38-inch jaw opening, can be incorporated in portable plants.

Austin Gyratory Crushers are made in six sizes, all of which are adapted for use in stationary plants, while the three smaller sizes can also be used in a variety of portable plants.

Western Portable Washing Plant



Western Portable Washing Plant.

This plant has solved a big problem for many users of washed aggregate by making possible the utilization of roadside material and saving the high cost of transportation from central washing plants.

The Western Plant has a capacity of 1,000 yards of accurately sized and perfectly washed gravel per day. Low in first cost, and exceedingly economical to operate, it will prove a revelation to those who have never expected that such capacity could be obtained from a 100% portable plant.

COMPARATIVE SPECIFICATIONS FOR WESTERN CRUSHING PLANTS

	Jaw Opening	Weight on Trucks	Rubber Tires, Solid	Rubber Tires, Pneumatic	Crawler Wheels	Power on Same Trucks	Length Feed Conveyor	Length Dischg. Conveyor	Shovel Loading Hopper
#80 Plant	9″x40″	32,000 Lbs.	20″x40″	13½″x24″ R. 8″ x36″ F.	Yes. 20 Ton	Optional	40′ to 100′	20′ to 100′	Yes
#90 Plant	9″x40″	41,100 Lbs.	20″x40″	13½″x24″ R. 8″ x36″ F.	Yes. 30 Ton	Optional	30′ to 100′	20′ to 100′	Yes
#100 Plant	9″x40″ 4″x40″	49,100 Lbs.	20″x40″	13½″x24″ R. 8″ x36″ F.	Yes. 30 Ton	Optional	30′ to 100′	20′ to 100′	Yes

COMPARATIVE SPECIFICATIONS FOR WESTERN CRUSHERS

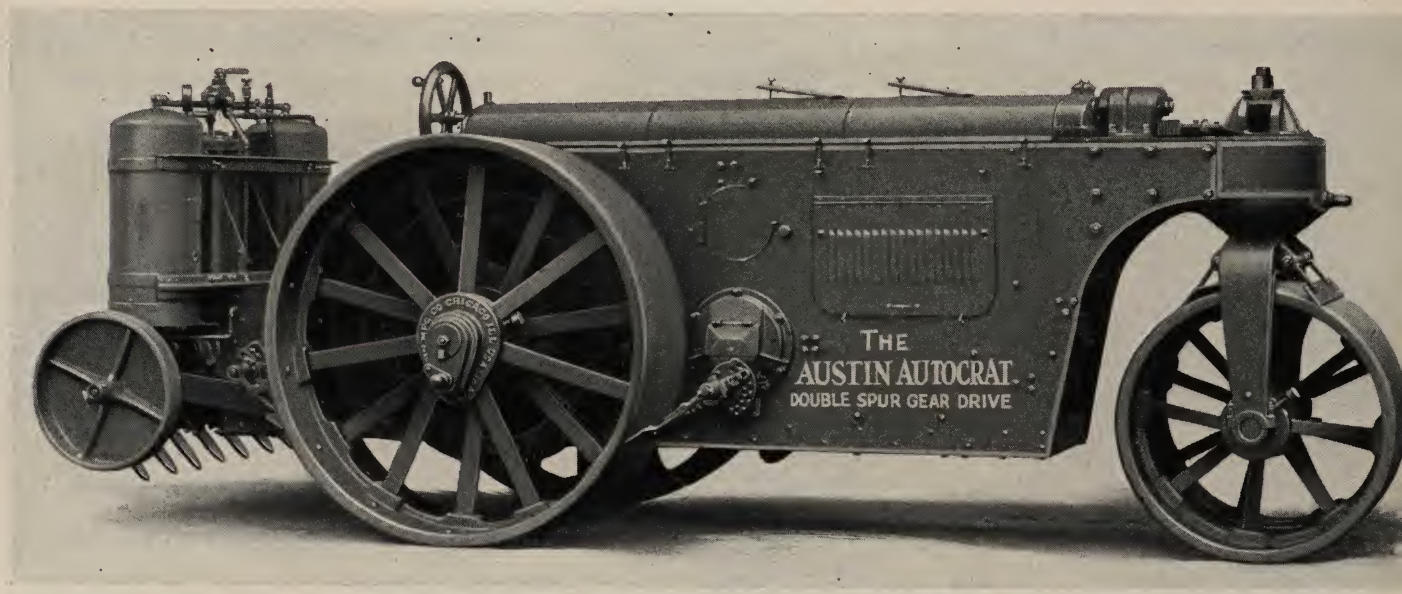
	No. 1 Aurora	No. 2 Aurora	No. 440	No. 940	No 1838
Size of Jaw Opening	9″ x 16″	11″ x 20″	4″ x 40″	9″ x 40″	18″ x 38″
Weight on Skids	9,600 Lbs.	10,500 Lbs.	8,000 Lbs.	14,000 Lbs.	25,000 Lbs.
Weight on Trucks	11,500 Lbs.	12,600 Lbs.	10,350 Lbs.	17,350 Lbs.	31,000 Lbs.
Power on Same Trucks	Optional	Optional	Optional	Optional	Optional

NOTE:—The right is reserved to change specifications without notice.

THE AUSTIN-WESTERN ROAD MACHINERY CO.

Home Office: 400 N. Michigan Ave., Chicago

BRANCH OFFICES AND WAREHOUSES IN PRINCIPAL CITIES



Austin 10-ton Autocrat Roller with Pneumatic Scarifier attachment

AUSTIN ROLLERS

The Austin Autocrat Roller is made in 10 and 12-ton sizes, and may be had with either gasoline or Diesel engine. Ample power is available for the hardest jobs of scarifying. The low center of gravity insures smooth work, while the short wheelbase increases maneuverability.

A differential gear is regular equipment. Special equipment includes electric starting, power steering and wheel sprinkling systems; also the powerful pneumatic scarifier shown in the illustration above.

The Austin Cadet Roller is made in 5, 6, 7 and 8-ton sizes, and in design is almost an exact duplicate of the Autocrat. In addition to a pneumatic scarifier attachment, the Cadet may be had with a front planing blade with patented runners, which hold it to a level course, and make of the Cadet an efficient leveler and street maintainer. Other special equipment includes electric starting and wheel sprinkling systems.

The Austin Pup Roller uses the Case tractor as its power plant; is made in 4 and 5-ton sizes, and may be had with planing blade, scarifier attachment, and canopy top.

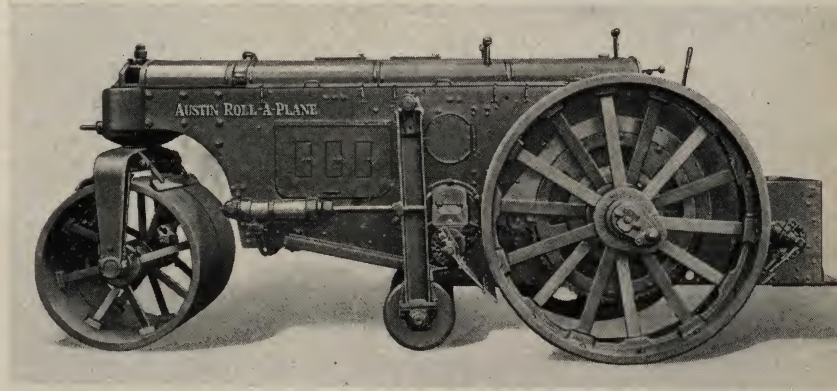
The Austin 4-cylinder Tandem Roller is made in 7 and 8-ton sizes, and is famous for its precision features, which insure smooth running and trouble-free operation.

Austin Roll-A-Plane

The Greatest Improvement Ever Made in Road Rollers

The center roller of the Roll-A-Plane adds years to the life of any black top pavement by producing an absolutely plane surface that is entirely free from the waves left by rollers of conventional design. Surface levelness on asphaltic and bituminous types of pavement is obtained equal to, or exceeding, that obtained on concrete.

The advantages of the Roll-A-Plane on construction are obvious. It reduces subgrade costs by simplifying the establishment of a smooth, regular grade line, and provides maintenance departments with a simple, effective and inexpensive means of ironing out wavy black top pavements during hot weather.



Austin Roll-A-Plane with center roller in operating position. The roller is hydraulically operated and can be raised out of the way when not wanted.

COMPARATIVE SPECIFICATIONS FOR AUSTIN ROLLERS

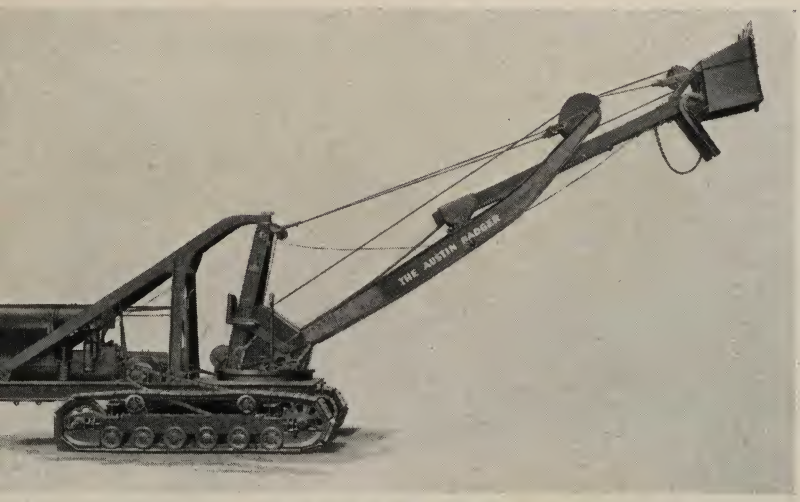
Weight	PUPS		TANDEMS		CADETS				AUTOCRATS	
	4–Ton	5–Ton	7–Ton	8–Ton	5–Ton	6–Ton	7–Ton	8–Ton	10–Ton	12–Ton
Loaded Weight—Plain	8,090 Lbs.	9,740 Lbs.	14,000 Lbs.	16,000 Lbs.	10,200 Lbs.	12,300 Lbs.	14,000 Lbs.	16,300 Lbs.	20,000 Lbs.	24,000 Lbs.
Loaded Weight—with Scarifier	8,690 Lbs.	10,340 Lbs.			11,720 Lbs.	13,820 Lbs.	15,520 Lbs.	17,820 Lbs.	23,500 Lbs.	27,500 Lbs.
Loaded Weight—with Planer	9,125 Lbs.	10,875 Lbs.			11,675 Lbs.	13,775 Lbs.	15,475 Lbs.	17,775 Lbs.		
Loaded Weight—with Planer and Scarifier	9,725 Lbs.	11,475 Lbs.			13,195 Lbs.	15,295 Lbs.	16,995 Lbs.	19,295 Lbs.		
Motor—H.P.	31	31	36½	36½	36.5	36.5	36.5	36.5	57	57
Speed in High Gear	3.12	3.12	3.20	3.20	3.67	3.67	3.67	3.67	3.18	3.18
Speed in Low Gear	2.19	2.19	2.02	2.02	1.10	1.10	1.10	1.10	1.05	1.05

NOTE—The right is reserved to change specifications without notice.

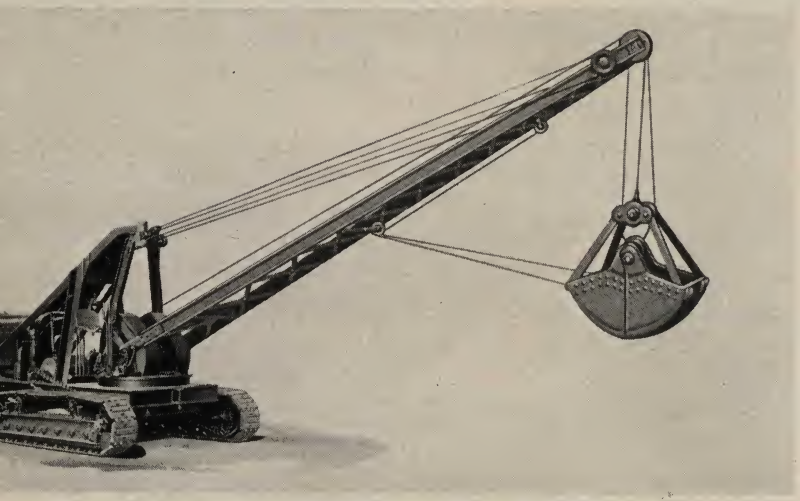
THE AUSTIN-WESTERN ROAD MACHINERY CO.

Home Office: 400 N. Michigan Ave., Chicago

BRANCH OFFICES AND WAREHOUSES IN PRINCIPAL CITIES



Austin Badger with shovel boom.



Austin Badger with crane boom and clamshell bucket.



Austin Badger Shovel photographed at the end of a 1600-mile cross-country trip.

The Austin Convertible Badger

Shovel—Crane—Clamshell—Backfiller —Dragline—Trench Hoe

The Austin Badger was designed to meet the demand for a shovel or crane light enough to be readily transported from job to job, strong enough to do really difficult work, yet decidedly lower in first cost and operating cost than larger units. That the Badger has met this demand is evidenced by its widespread and constantly increasing acceptance.

Convertibility from shovel to crane, or vice versa, is easily and quickly accomplished, while transportation from job to job is simplified by the special wheel mounts, shown in the photograph at the bottom of the page, which make it possible to move the Badger at motor truck speeds, and for any desired distance.

As compared with other shovels in its class, the Badger, with its 15-foot curved boom, provides from 1 to 2 feet more digging range and dumping height, while the 11 cubic foot dipper digs at least one additional cubic foot of material per bite. The independent roller chain crowd affords positive dipper stick control and speedy, powerful action.

The crane boom and trench hoe use the same chassis as the shovel. The crane boom is regularly 25 feet long, but may be had, if desired, with 10-foot extension. The use of this boom converts the Badger into either a dragline, clamshell, backfiller or magnet, in addition, of course, to work that may be done with the usual crane hook.

The universal popularity of the Badger is due primarily to its wide range of use, which includes highway construction and maintenance, irrigation and drainage, stone and gravel handling, clay digging, material handling and erection, and miscellaneous excavation.

THE AUSTIN-WESTERN ROAD MACHINERY CO.

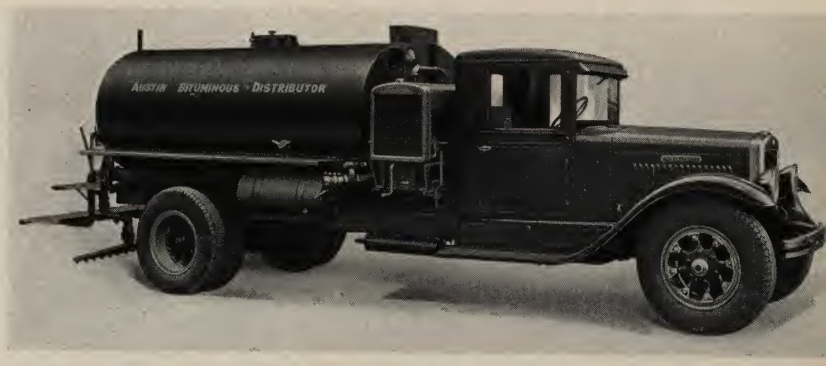
Home Office: 400 N. Michigan Ave., Chicago
BRANCH OFFICES AND WAREHOUSES IN PRINCIPAL CITIES

Austin Bituminous Distributors

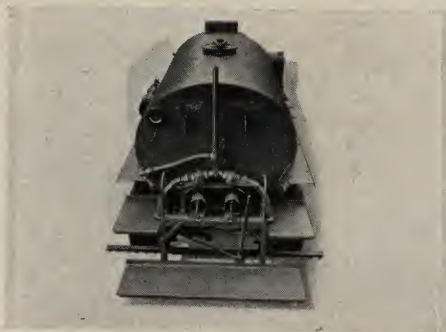
Austin Bituminous Distributors are designed to handle all grades of oil, tar and asphalt used in the construction and maintenance of bituminous road surfaces. The standard model is made in 600, 800, 1000, 1200 and 1500 gallon capacities, while the Junior model is made in 400, 500 and 600 gallon capacities. All models are suitable for mounting on trucks, trailers or semi-trailers.

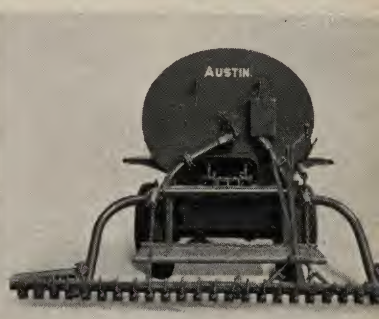
The detachable type of manifold is standard equipment, but the full circulating boot type may be had, if wanted. Motors are mounted in front, which not only provides better load distribution, but also eliminates fire hazard and removes the motor from the mist which causes ignition and other troubles.

The fifth wheel tachometer furnished on special order is the most accurate device known for insuring absolute accuracy in the rate of application.



Austin Bituminous Distributor, showing front mounting of power unit.



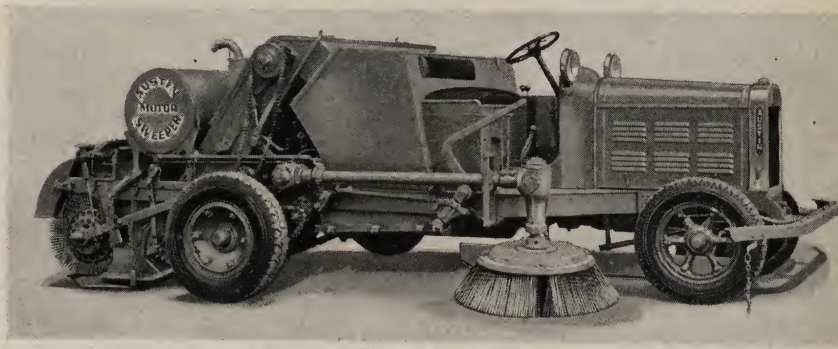


Rear views of Austin Distributors with standard, quick-detachable, and full circulating manifolds.

Austin Motor Pickup Sweeper

The Austin Motor Sweeper has the 4-wheeled chassis which is preferred by automotive engineers. It also has a squeegee type of beltless elevator which operates with remarkable efficiency and economy, and an extra large, 2-speed oscillating gutter broom.

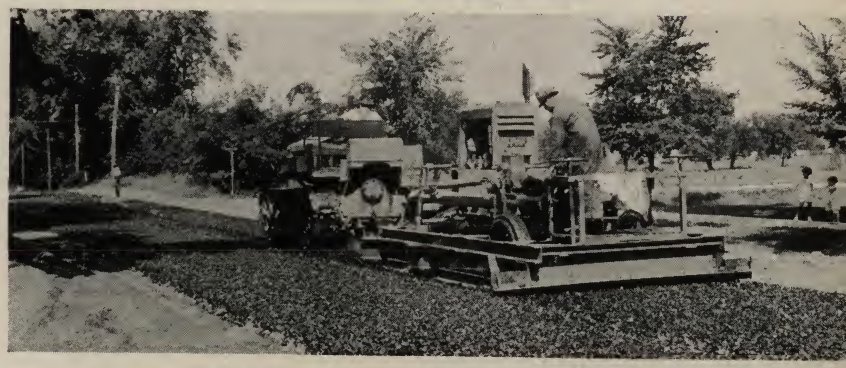
The over-all height of the 1934 model has been so reduced as to provide unequaled visibility in all directions. Another important improvement consists of hydraulic controls for raising the elevator and large pickup broom.



Austin Motor Pickup Sweeper.

Sweepers, Sprinklers

Austin Standard Sweepers and combination Sprinkler-Sweepers are made in both front truck and direct hitch styles. Horse-drawn Water Sprinklers are made in 600 and 450-gallon sizes, while units for mounting on motor trucks are made in 750 and 1,000-gallon sizes, as well.



The Western Road-Mix machine in operation.

Western Road-Mix Machine

This is a "once-over" machine, which does a complete job of mixing the aggregate and bituminous material, leaving each particle of the aggregate thoroughly and uniformly coated. Mixing is by means of a series of "V" blades and pug mills. The spreader blade at the rear leaves the mixed material smooth and uniform in thickness.

THE AUSTIN-WESTERN ROAD MACHINERY CO.

Home Office: 400 N. Michigan Ave., Chicago

BRANCH OFFICES AND WAREHOUSES IN PRINCIPAL CITIES



Austin 48" Hydraulic Control Contractor's Special Elevating Grader



Western No. 6 Elevating Grader



The Western Shouldering Attachment in action.

Austin Contractor's Special Elevating Graders

The latest Contractor's Special models are the finest of a long line of Austin elevating graders which had its start with the wood frame machine of 1866.

Both the 42-inch and 48-inch models may be had with either power take-off or engine carrier drive; with either chain or shaft driven carriers, and with either the conventional type of hand operated plow and carrier controls, or with the new hydraulic controls which function with maximum ease and efficiency.

Western No. 6 Elevating Grader

The Western No. 6 is made in both 42" and 48" carrier widths, and is available with either hand or power operated plow and carrier controls.

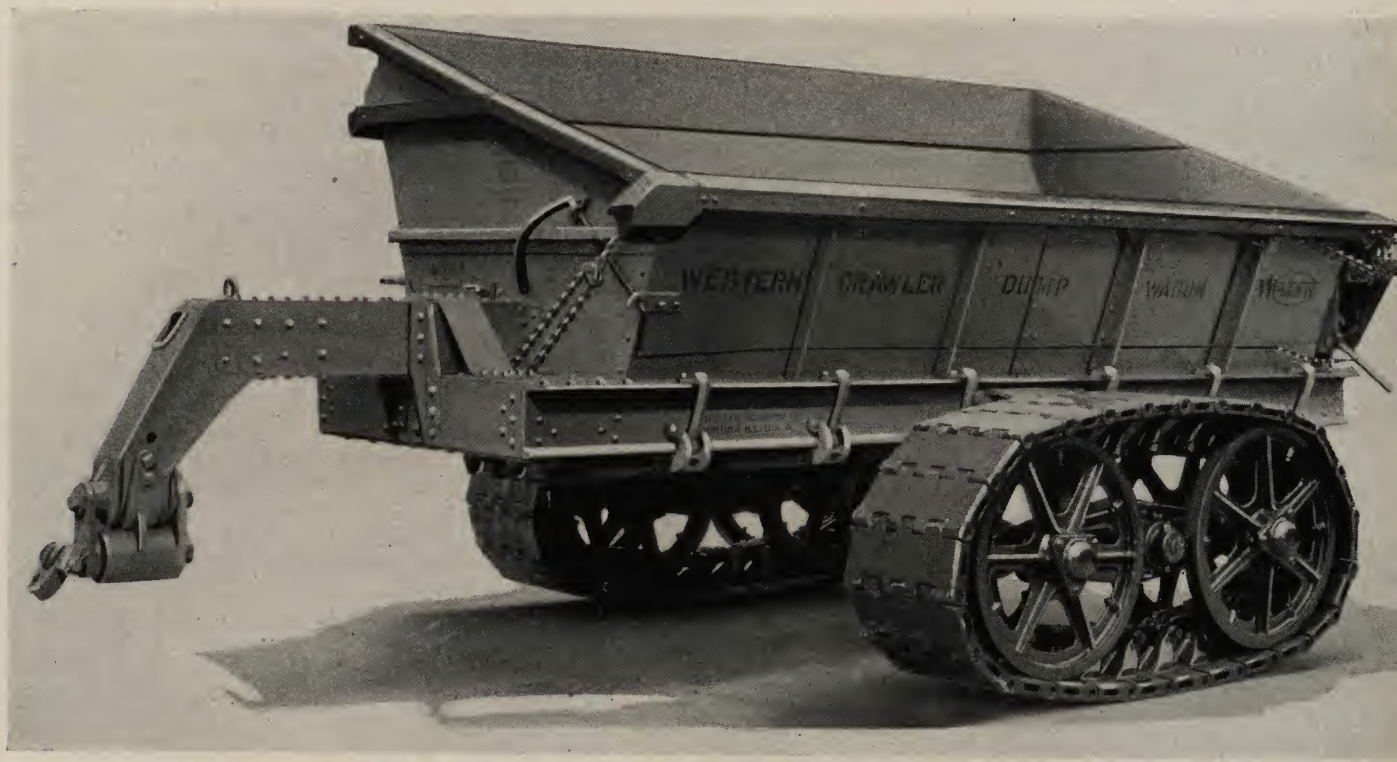
The most distinctive feature of this modern elevating grader is its extremely rigid 10" tubular steel "backbone," in combination with the 3-point suspension provided by a massive ball and socket front end connection. Another excellent feature is the stiff leg plow control, which is especially advantageous when the going is hard.

When fitted with the special shouldering attachment shown in one of the illustrations, the No. 6 will build a shoulder true to line and grade, and at the same time load the excess material. Heretofore such work has necessitated either a special machine usable for no other purpose, or the handling of excess dirt by slow and costly methods.

THE AUSTIN-WESTERN ROAD MACHINERY CO.

Home Office: 400 N. Michigan Ave., Chicago

BRANCH OFFICES AND WAREHOUSES IN PRINCIPAL CITIES



Western 10-13 yard Crawler Dump Wagon with top box set for elevating grader loading.

WESTERN CRAWLER DUMP WAGONS

These wagons, with their remarkable operating efficiency under any and all conditions, have long been popular with experienced earth movers. Probably their most distinctive feature is the unique Spring Wind-Up, which is controlled from the tractor or the ground, and substitutes the instantaneous action of a heavy coil spring for manual labor in winding up the doors after dumping. Its simplicity and reliability are of distinct advantage, as is also the fact that it operates with equal efficiency at all temperatures.

In addition to the well-known 5-7 yard and 7-9 yard models, the Western line now includes a 10-13 yard wagon, which is the answer to a demand for a direct hitch, spring wind-up crawler wagon of tremendous capacity. It is built extra heavy and strong throughout, has an exceptionally wide door opening, and can be quickly converted from the shovel loading to the elevating grader loading type. The Western Crawler Wheel has been especially designed to reduce the cost of crawler wagon operation. It is easy running and self-cleaning; has replaceable tires on the track wheels, and is easily and inexpensively maintained.

Western 1½ and 2-Yard Wagons

These wagons are noted for their strength and easy running qualities. Materials of the highest quality are used throughout. Lightness of draft is secured by a short coupling, which, at the same time, increases strength and is easier on the team. Wagons of these sizes still have their place on certain jobs, especially under present-day conditions, and there are no better wagons than Westerns.



Western Contractor's Dump Wagon with three-up hitch.

COMPARATIVE SPECIFICATIONS FOR WESTERN CRAWLER DUMP WAGONS

Size	Wheels	Wheel Tread Out to Out	Body Width Inside at Top	Body Width Inside at Bottom	Body Depth Inside	Body Length Inside	Overall Width	Overall Height	Discharge Opening	Approximate Weight
5- 7 Yard	Western 20-Ton	8′ 3½″	5′ 6″	3′ 8″	2′ 9⅝″	9′ 11″	8′ 7½″	5′ 3″	3′8″x 9′11″	11,310 lbs.
7- 9 Yard	Western 20-Ton	9′ 0″	6′ ⅞″	3′ 8″	3′ 6″	11′ 11″	9′ 7″	6′ 0″	3′8″x11′11″	12,900 lbs.
10-13 Yard	Western 25-Ton	9′ 5½″	6′ 6¼″	4′ 4″	4′ 2⅛″	11′ 11″	9′ 11¼″	6′ 11½″	4′4″x11′11″	15,750 lbs.

NOTE: The right is reserved to change specifications without notice.

THE AUSTIN-WESTERN ROAD MACHINERY CO.

Home Office: 400 N. Michigan Ave., Chicago

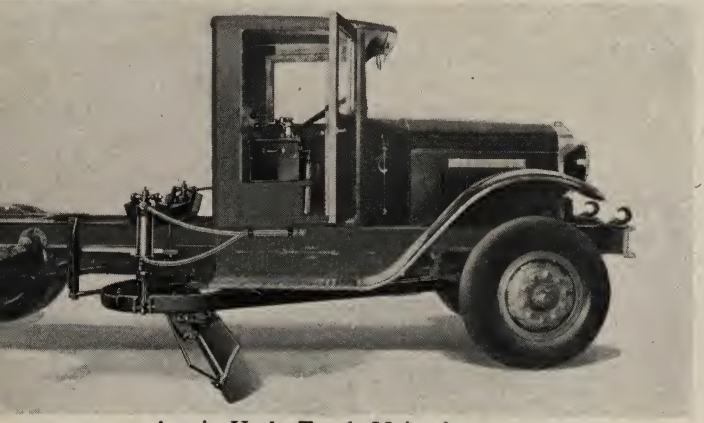
BRANCH OFFICES AND WAREHOUSES IN PRINCIPAL CITIES



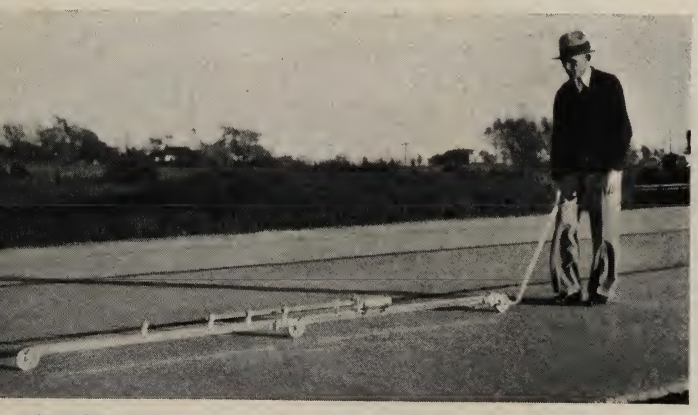
Austin Rip-Rooter



estern No. 1½ Straight Blade Snow Plow on Chevrolet Truck



Austin-Hyde Truck Maintainer



Checking Concrete with an Austin Surface Inspector

Austin Rip-Rooter

This handy 1750-lb. tool rips like a road ripper, roots like a gang rooter, is light in weight for the work it accomplishes, low in price when compared with tools of equal efficiency, and has its place in almost every road building or maintenance outfit. All seven teeth, or any portion of them, may be used, and the Rip-Rooter is equally efficient behind small, medium-sized or large tractors.

Western Truck Snow Plows

Western Snow Plows for 1½-ton trucks are built in two general types; one with long push members which carry the thrust to the truck side sills back of the cab, and the other with connection direct to the front end of the truck side sills. Reversible and non-reversible blades are available; also worm and gear or hydraulic lifts, and both spring and toggle blade releases.

Western Snow Plows for 2-ton to 5-ton trucks are made in both straight blade and "V" blade types. The straight blade is available in 21-inch and 30-inch heights, with or without top extension. Both hand and hydraulic raising mechanisms are available.

The "V" blade plow may also be had with either hand or hydraulic lift, and with or without wings. Straight and "V" blade plows fit the same frame, saving money for the owner, and making it possible for him to use whichever type of plow is required by varying conditions.

Western Tractor Plows

The Western line includes straight and "V" blade plows and sidewalk plows for the Model 35, 20-C, and 15 Cletrac Tractors. All are hydraulically controlled.

Austin-Hyde Truck Maintainer

This handy and efficient maintainer combines unique blade design and hydraulic power controls with truck speed to do a quick and effective job of road maintenance. As on a motor grader, the circle and blade are pulled, not pushed. The edge of the blade actually planes the surface and does not drag along like a spring blade.

The hydraulic controls are smooth, fast and positive. They not only raise and lower the blade, but also hold it rigid while the truck is in motion, with the result that high spots are cut off and holes filled without gouging the surface.

Austin Surface Inspector

The Surface Inspector takes all the guess out of finishing. It checks the smoothness of newly laid concrete before the permanent set takes place, and automatically indicates any high or low areas. It is equally efficient on the hardened concrete or on black top, and can be used to excellent advantage to check the accuracy of alignment of side forms. An electric buzzer sounds a warning signal whenever surface irregularities exceed the specification limit.

The Surface Inspector is a necessity for engineers and a boon to contractors.

THE AUSTIN-WESTERN ROAD MACHINERY CO.

Home Office: 400 N. Michigan Ave., Chicago

BRANCH OFFICES AND WAREHOUSES IN PRINCIPAL CITIES

Western Power Wheelers

The Western Power Wheeler is self-loading and handles almost any material except rock on either long or short hauls. While often used as an auxiliary unit with large outfits, it is also economical to use the Western Power Wheeler exclusively on smaller jobs. It is made in two sizes, with rated capacities of 2 yards and 1¼ cubic yards. An automatic end gate prevents spillage and a trip is seldom made without a heaped load, which increases the rated capacity.

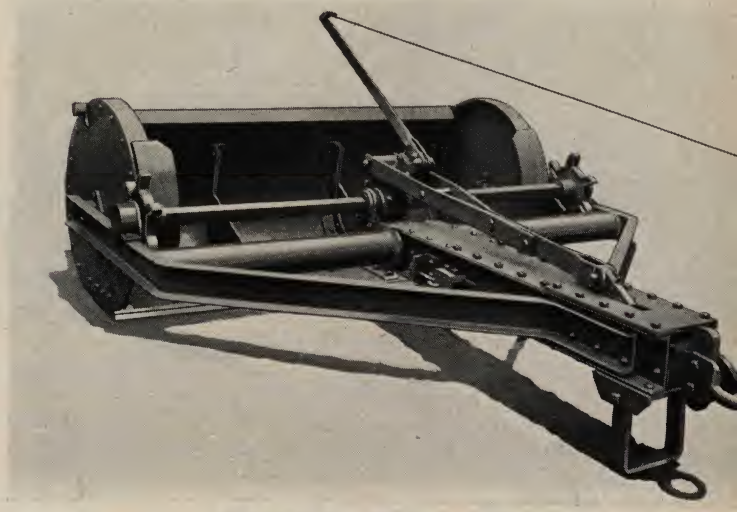
Control is through a single lever, or rope to each unit, if operating in a train. The pan drops to the loading position by gravity, and is raised by power transmitted from the wheels through clutches.



Western 2-Yard Power Wheeler

Western Rotary Fresnos

Western Rotary Fresnos are made in six sizes, with sufficient variation in capacity to provide a model for each size of crawler tractor. Rotary fresnos make excellent finishing tools behind tractors of from 15 to 30 horsepower, while the 7-foot No. 60 Rotary Fresno is a large cut-and-carry tool for use with the most powerful tractors.



Western No. 60 Rotary Fresno

Western No. 35 Bulldozer

The Western No. 35 Bulldozer is designed for use with the Cletrac "35" Tractor. The blade is hydraulically controlled, the handle operating the 4-way valve being within easy reach of the driver. The blade has a high lift and a low undercut; can be held at any point up or down, or allowed to float. There is pressure on the blade in both directions.

Wheelers and Scrapers

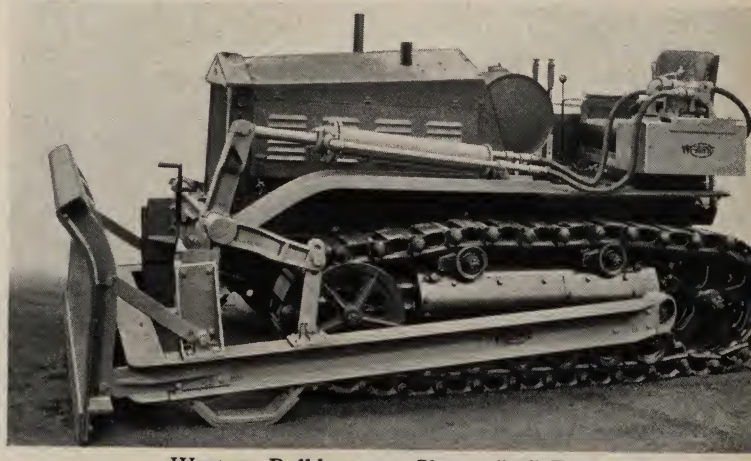
The Western line of tools includes Standard and Township Wheelers; Horse Drawn Fresnos; Drag Scrapers and plows. All are made in a wide variety of styles and sizes.

Road Drags

Western Road Drags are made in two-blade and three-blade styles. Three-way outfits are composed of two side drags and either a rear drag or pair of crowning chains.

Austin Culverts

Austin Super Iron and Super Steel Corrugated Galvanized Culverts are manufactured in a wide range of gauges and diameters, and are designed to meet all federal and state specifications.



Western Bulldozer on Cletrac "35" Tractor

"Cutting Edges"

AWCO blade bits, or cutting edges, are made to fit all makes of road and motor graders, maintainers, drags, bulldozers, trail builders, etc., etc.

THE BARRETT COMPANY

40 Rector Street, New York, N. Y.

Manufacturer of Tarvia

New York	Baltimore	Philadelphia	Birmingham	Boston
St. Louis	Chicago	Portland, Me.	Bethlehem	Columbus
Detroit	Cleveland	Syracuse	Toledo	Rochester
Minneapolis	Milwaukee	Cincinnati	Lebanon	Buffalo
Youngstown				Hartford

In Canada:

THE BARRETT COMPANY, Ltd.

Montreal	Toronto	Winnipeg	Vancouver

PRODUCTS: Tarvia, Tarvia-lithic, Hot Surface Applications, Cold Surface Applications, Hot Binder, Cold Patching Binder, Joint Filler. Also Creosote Oil, Dust Preventives, Road Tars, Bituminous Paint, Waterproofing

Tarvia is made only by The Barrett Company, America's oldest and most experienced manufacturer of coal-tar road-building materials. Barrett draws crude tars from many sources, carefully classifies and grades them, and refines Tarvia exactly suited to the purpose for which it is to be used. The Tarvia offered to meet users' specifications must first of all meet Barrett's own rigid, self-imposed specifications.

The result is a degree of uniformity and dependability in Tarvia which ordinary road tars do not duplicate. This, plus Barrett's unmatched delivery and application service and the helpful co-operation of experienced Tarvia field men, is definite assurance of consistently satisfactory results.

Tarvia
GOOD ROADS at LOW COST

Trade-Mark Reg. U. S. Pat. Off.

"Tarvia-A" for Hot Surface Application

A highly refined product which has been especially developed for hot surface treatment work. "Tarvia-A" gives a hard, rugged, impervious surface which will not wave, push or roll. Its granular, skid-safe quality is a factor of great importance on roads subject to heavy and continuous rubber-tired traffic.

Among the services performed by "Tarvia-A" is the top-surfacing of cement roads, a precautionary measure which greatly adds to their life.

Specifications for the application of "Tarvia-A" will be gladly furnished on request.

Tarvia "Re-Tread"

A special grade of Tarvia developed and prepared for the binder for Tarvia "Re-Tread" pavement, a mixed-in-place Tarvia and stone top coating for macadam, shale and gravel roads. This type of pavement was originated and developed by The Barrett Company. No comparable type of pavement can be built so cheaply and with so little expensive equipment—yet Tarvia "Re-Tread" will stand a surprising amount of traffic. Results are uniformly satisfactory. An illustrated Tarvia "Re-Tread" booklet will be sent on request.

"Tarvia-B" for Cold Applications

"Tarvia-B" is a refined tar product especially prepared for cold surface application. Its action is to penetrate deep into the top surfacing of gravel and macadam pavements, binding the particles solidly together.

"Tarvia-B" is the outstanding material for surface treatment and maintenance of gravel roads. It completely changes the dusty, loose gravel surfaces into smooth, tough, impervious, skid-safe roads, totally free of dust and the common rut-wave ailment of this type of pavement.

"Tarvia-B" is suitable for use both as prime coat and top-surface treatment on macadam roads. It is especially suited for roads carrying a large amount of horse-drawn, steel-tired traffic.

Specifications for the application of "Tarvia-B" and booklets describing its use will be sent on request.

"Tarvia-X" for Hot Binder

"Tarvia-X" is one of the strongest and most dependable waterproof binders used in the construction of roads and pavements. It is applied by the penetration method and is particularly adapted to a wide variety of specifications which apply to city and suburban streets, and state and county roads. "Tarvia-X" is shipped in steam-coil equipped tank cars and requires but ordinary steam pressure to heat it to its correct application temperature.

Roads bound with "Tarvia-X" are durable, dustless, skid-safe, and do not rut, wave or roll.

"Tarvia-X" is especially easy to handle on the road. It penetrates quickly into the stone-course and serves to bind it together firmly.

"Tarvia-X" is a standard material for hot patching and repairing all types of pavements. It is particularly excellent for patching bituminous macadam and bituminous concrete in preparation for surface treatment.



Main Street, Keene, N. H. "Tarvia-B" treated gravel.



Seneca Trail, Mercer County, W. Va. Tarvia "Re-Tread."



Minnehaha Avenue, Minneapolis, Minn. "Tarvia-X," 1920.



Fayetteville Street, Raleigh, N. C. "Tarvia-lithic."

"Tarvia-XC" is a special grade of Tarvia supplied for sealing up the cracks and open joints in cement concrete pavements. It is also extensively used for general repairing, holes, ruts, etc., and for building up corners of concrete that have failed. Wide cracks should be filled with another special preparation called Plastic "Tarvia-XC." Descriptive booklets and specifications for the use of "Tarvia-X" and "Tarvia-XC" will be mailed on request.

"Tarvia-KP" for Cold Patching

"Tarvia-KP" is the "old reliable" of maintenance preparations. It has been especially prepared for the patching and preservation of all pavements.

When mixed with the proper aggregate "Tarvia-KP" forms a mixture which makes a strong, lasting patch. It may be easily mixed by hand or in an ordinary concrete mixer. "Tarvia-KP" can be applied immediately.

"Tarvia-KP" costs less because it goes farther. The high binder content in it permits greater coverage per cubic yard than ordinary patching material. Heating is not necessary. It is applied cold.

There are innumerable uses for "Tarvia-KP." It is excellent for building up mat coats over plank floors on bridges, for paint coating cement gutters, for widening and resurfacing old pavements, for sidewalks, for emergency patches, for waterproofing concrete, for station platforms and grade crossings, and for the surface treatment of all types of pavement.

An illustrated booklet giving the complete data on how to make a proper "Tarvia-KP" mix will be sent on request.

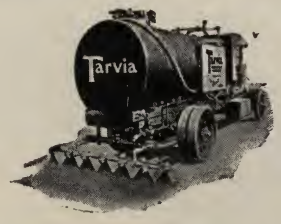
"Tarvia-lithic," the Ready-to-Lay Pavement

"Tarvia-lithic" is a combination of selected aggregate and a special grade of Tarvia manufactured in a central mixing plant, and shipped to the job to be used without heating or further treatment.

"Tarvia-lithic" is made in three sizes—the 1½-inch, or coarse size, used for black base, foundations, and wearing courses; the ¾-inch, or intermediate size, used for light wearing courses and patching; and the chip, or fine size, ordinarily used for spreading over the coarser mixtures filling the voids and making a hard, tough pavement. It is also used for patching.

"Tarvia-lithic" has a variety of miscellaneous uses such as private drives, walks, parking spaces, tennis courts, playgrounds, handball courts, railway crossings, station platforms, bridge floors, etc.

The Barrett Company maintains a special department entirely devoted to "Tarvia-lithic" development. Detailed illustrated booklets and specifications covering all its uses have been prepared, and will be mailed upon request.



The Barrett Company maintains a fleet of modern pressure distributors for the application of Tarvia. These are available at many of the Company's plants and service stations.

BLAW-KNOX COMPANY

2021 Farmers Bank Building, Pittsburgh, Pa.

BRANCH OFFICES

NEW YORK, 342 Madison Ave. — PHILADELPHIA, 906 Widener Building — CHICAGO, Peoples Gas Building — BIRMINGHAM, Brown-Marx Building

Export Division: Blaw-Knox International Corporation, Pittsburgh, Pa.

London, England, New Oxford House, Hart Street Holborn, W. C. 1.—Paris, France, 1 Rue de Clichy

BLAW-KNOX CONSTRUCTION EQUIPMENT INCLUDES

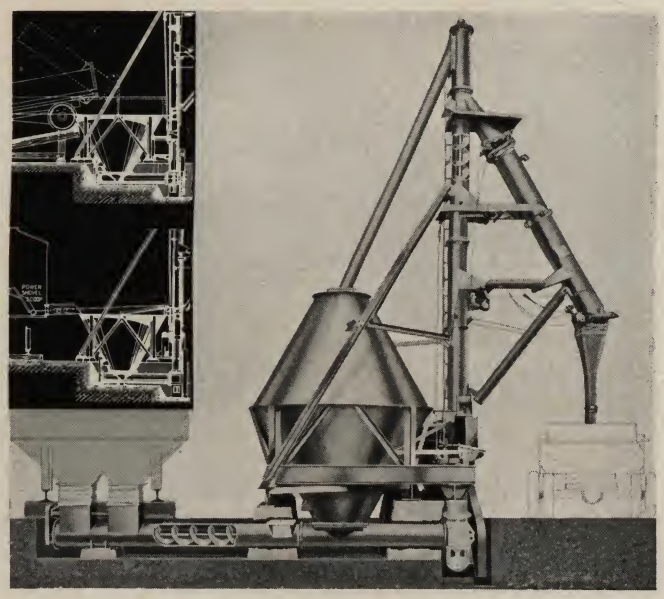
Road Forms—Weighing Batcherplants—Central Mixing Plants—Trukmixers—Dirt Moving Machinery—Bulk Cement Plants—Finishing Machines—Steel Forms for General Construction—Clamshell Buckets—Concrete Buckets—Street and Sidewalk Forms—Truck Turntables—Asphalt Plants



Blaw-Knox Batcherplant

for storing and measuring sand and stone

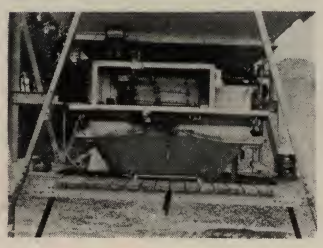
A complete line of self-cleaning steel bins for storage and batching and for any capacity. Equipped with batching equipment, as desired. Easily and cheaply erected and dismantled.



Blaw-Knox Automatic Aggregate Batcher

for three materials

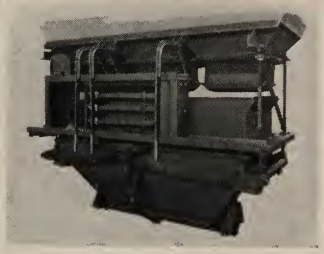
This batcher is designed for installation on any Blaw-Knox Bin. It is equipped with three ½ hp. electric motors, one for each bin gate, a three-beam scale, springless dial indicator and electrical control box. Further details will be furnished upon request.



Blaw-Knox Bulk Cement Plants

Storage capacity of 50 to 350 bbls. Can be furnished for manual or automatic operation.

Adaptable to delivery of bulk cement by box car, by truck, or from hopper bottom cars, with only minor and economical changes to accommodate each particular job. Complete details of this interesting plant will be sent to you on request.



Blaw-Knox Weighing Batcher

for the measurement of aggregates by weight

It is fast, accurate, reliable and is perfected to meet all the requirements of the concrete construction industry. Shipped completely assembled for installation on any bin.



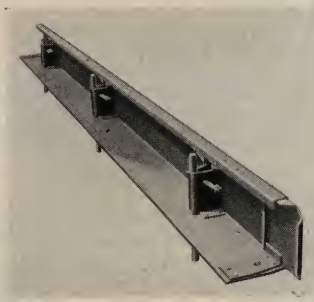
Blaw-Knox Cementanks

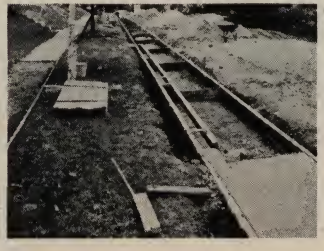
For the hauling of bulk cement in batch trucks

The Blaw-Knox "Tip-over" CEMENTANK will fit any truck body. It is moisture-proof and fool-proof. It can not be accidentally overturned. It is built strong enough to withstand the abuse of trucking operation.

Blaw-Knox Road Forms

Stronger, better than ever, with reinforced Lock Joint. Blaw-Knox DREADNAUGHT Road Forms are made from 3/16 inch steel plate. The patented Lock Joint connection keeps the forms true to line and grade. Extremely easy to set and dismantle.





Blaw-Knox Universal Forms

For curbs, curbs and gutters and sidewalks. These forms are interchangeable and can be combined for any type of road and street work. They are extremely easy to set and dismantle.

Blaw-Knox Asphalt Plants

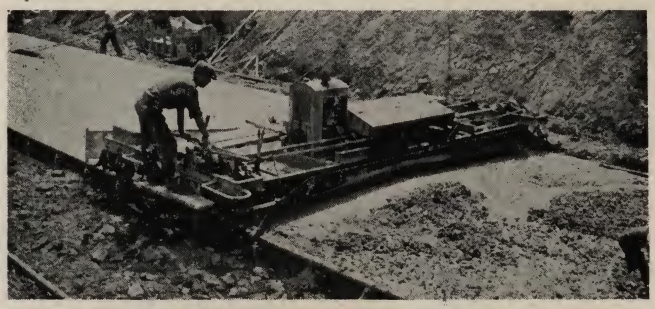
Blaw-Knox (Madsen) Portable Asphalt Plants are designed for economical road building operations. They are designed for quick portability from job to job; low first cost and big production are features of Blaw-Knox Plants which are valuable to contractors. Complete details of these interesting plants will be sent to you upon request.





Blaw-Knox Gas-Electric Finisher

The Gas-Electric Drive Finisher is the foremost development in finishing equipment for concrete roads. It is a self-contained unit; a moving power plant—generating its own power with ample electrical capacity for the operation of floodlights on the job if desirable. The machine is adjustable for varying widths of roads; screeds have been improved, and provision is made in the machine for the attachment of a tamper or a Blaw-Knox Vibrator, when such attachments are desired. Complete details of the new Blaw-Knox Electric Finisher will be sent upon request.



The Ord Concrete Road Finisher

The Ord Road Finisher produces a smooth, perfectly finished road. The double screed action spreads and kneads the concrete into place with minimum vibration to disturb the side forms. There is no segregation of concrete. The Ord Finishing Machine is made in any width for the construction of both concrete and asphalt roads. It can, with slight modification and at small expense, be adapted for bituminous paving—any hot or cold mix. It can be furnished with single screed; with double screed; with single screed and tamper, or with double screed and tamper. It is convertible to any desired combination including the attachment of a Blaw-Knox Vibrator.

Clamshell and Dragline Buckets

A complete range in sizes of Clamshell Buckets for rehandling and light excavating; for hard digging, and cleanup work, ranging in capacity from ⅛ to 4 cu. yds. Completely equipped with ballbearing sheaves.

Blaw-Knox DRAGLINE Buckets are available in 28 regular sizes—from ⅜ to 6 cu. yds. capacity. Catalogues will be sent upon request.





Blaw-Knox Concrete Buckets

This unique concrete bucket is finding widespread favor among contractors. This easy operating roller gate bucket is the only concrete bucket which will satisfactorily handle present day concretes, for instance, those containing 27 to 30 gallons of water per cu. yd.

Blaw-Knox Vibrator

Designed for attachment to any Blaw-Knox or Ord Finishing Machine (old or new) and in any width. With the Blaw-Knox Vibrator honeycombing in the slab is eliminated. It produces a well compacted, dense slab. Its ability to do a proper job has been demonstrated on actual paving work.





Blaw-Knox Trukmixer

The last word in self-contained automatic control. Combines the proved principles of stationary mixing with the economies of transit mixing. End to end mixing through automatic reversal of the drum. Accurate and automatic forced feed water measurement. The Blaw-Knox Trukmixer assures quality concrete under all conditions with fast mixing action. It is made in 1, 1½, 2, 3, 4 and 5 cu. yd. sizes. As an agitator, it is made in 1, 2, 3, 4, 5, 6 and 7 cu. yd. capacities.

Complete information on Blaw-Knox Trukmixers will be sent upon request.

Blaw-Knox Steel Forms

For general concrete construction. Contractors use Blaw-Knox Steel Forms to speed construction and maintain their working schedule. They have been in widespread use for twenty-seven years in the construction of bridges, tunnels, dams, subways, sewers, walls, sewage disposal plants, aqueducts, piers, caissons, locks, etc.







Blaw-Knox Turntable

One man can turn any size truck with this equipment. The turntable swings out and over the road forms, permitting two-way traffic on the subgrade. It is made in several sizes for the accommodation of any size truck.

Blaw-Knox Dirtmover

The Blaw-Knox Hydraulic Dirt Mover puts dirt moving and grading costs down where they belong. In many cases, as low as 5 cents per cu. yd. It is made in a full range of sizes for all tractor capacities.

The Blaw-Knox Bulldozer

Two way control—hidden, protected power. The operating mechanism is enclosed in the side arms for protection from dust and damage.

The Bulldozer bowl is scientifically designed to the correct curvature to cause a lifting and rolling action to the dirt.



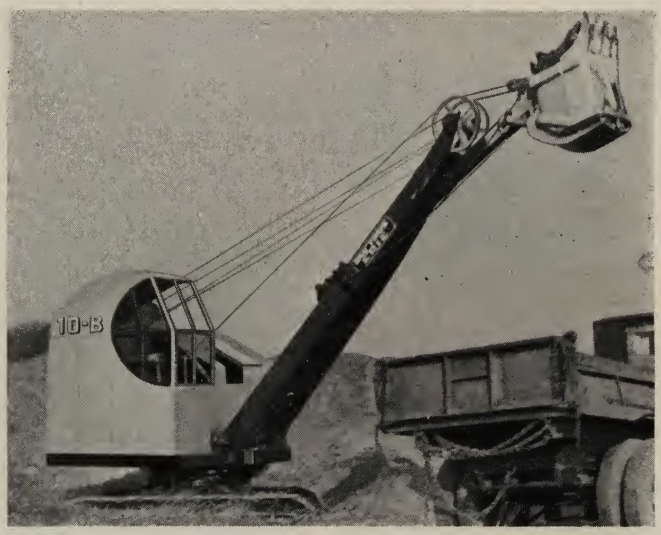
BUCYRUS-ERIE COMPANY

SOUTH MILWAUKEE, WIS. ERIE, PA. EVANSVILLE, IND.

BRANCH OFFICES: Buffalo, N. Y.; New York, N. Y.; Boston, Mass.; Philadelphia, Pa.; Pittsburgh, Pa.; Chicago, Ill.; St. Louis, Mo.; Kansas City, Mo.; Birmingham, Ala.; Dallas, Texas; San Francisco, Cal. Representatives and service stations throughout the United States.

BUCYRUS ERIE

BUCYRUS-ERIE offers to the road-builders a complete line of up-to-date excavating equipment in all sizes and types. Convertible excavators from ⅜-yard to 2¼-yard are built specially for road building, while the complete Bucyrus-Erie line goes on up to the giant 20-yard machines. Each road-building excavator is available as shovel, dragline, clamshell, or lifting crane. Pile driving equipment can also be provided, and the smaller machines are offered with skimmer or dragshovel. Power includes gasoline, Diesel, electric, gas-air, and steam. Special high altitude engines are available.



Famous for their dependable performance, machines built by Bucyrus-Erie have long been favorites with highway builders. The present line consists of up-to-date models developed during the past three years and thoroughly tested and proved.

Special features include: Bucyrus-Erie special heat-treated alloy steels, single-shaft-drive mounting, ball or roller bearings at all vital points, special design to secure great strength with elimination of dead-weight, simplicity, ready accessibility of parts for lubrication and adjustment, transmissions fully enclosed and running in oil, convenient field convertibility, compactness for close clearances and to permit rail shipment without dismantling, conservative power and crane ratings, easy control for accurate grading, an extremely fast digging cycle with quick acceleration and deceleration, steering control from cab, large sheaves for long rope-wear, power dipper-trip, full-vision cab, oversize brakes and clutches, cast-front inserted-tooth dipper rated at struck measure.

Whenever you need an excavator for road-building, whether shovel, clamshell, or dragline, be sure to get in touch with Bucyrus-Erie. Get complete specifications on the machine you need and compare it for balanced value with any other machines you may consider.

General Utility, Convertible Machines, Diesel, Gasoline or Electric

MODEL	As shovel with standard front end combinations			Working Weight (Pounds)	As dragline or clamshell		Crane rating	Caterpillar Mounting		Engine Approx. H.P.
	Dipper size cu. yds.	Boom length	Handle length		Bucket size (cu.yds.)	Boom length	in pounds at 12′ radius	Regular bearing area (sq.ft.)	Over size area (sq.ft.)	
10-B	⅜	13′6″	11′0″	16,200	⅜	28	5,240	12.9	18.	35-52
16-B	½	16′6″	12′6″	30,500	½	35	12,200	23.5	60.0	54
1020	½	18′0″	13′0″	46,000	½-¾	35	16,500	23.5	36.8	54
21-B	¾	18′6″	14′0″	55,300	¾-1	35-40	22,000	28.4	37.5	76
32-B	1	20′0″	15′0″	74,100	¾-1¼	40-55	33,000	35.6	47.5	105
37-B	1½	21′6″	15′0″	95,000	¾-1½	45-60	49,400	41.0	58.3	121
43-B	1¾	22′0″	16′0″	110,800	¾-2	45-70	61,400	51.8	70.8	135
52-B	2¼	27′0″	18′0″	161,000	1½-3	50-80	87,000*	78.0	122.5	190
GA-3	1¼	21′3″	14′0″	72,500	¾-1	40-45	25,600*	42.0	—	95
							*At 15′ radius.			

THE BURCH CORPORATION

Crestline, Ohio

Manufacturers of Road Building and Maintenance Equipment



THE ROSS SNOW PLOW

The Ross Plow embodies all the advantages of the most perfect of snow plows and is without the troublesome features that are common to other makes of snow plows.

First, the Ross Plow has a moldboard with a peculiar pitch and curve and will mold and roll the snow in much the same manner as a field plow, and where possible to acquire any speed with the truck will deposit the snow entirely clear of the road surface frequently as far as or over the fence.

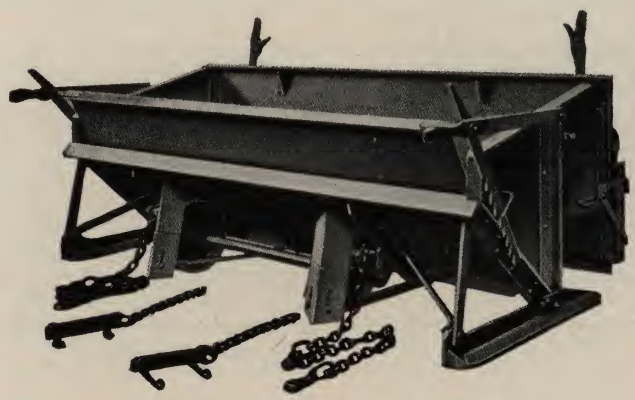
Remember, the Ross does not shove the snow. The entire construction of the Ross is unusually rigid, with push tubes extending back to rear axle, therefore, deriving its ability to push through deep snow directly from the seat of the power of the truck.

The front hitch on the Ross is so constructed that the plow proper may be connected at one side of the center and with a brace extending from the out end of the plow to the push tubes immediately in front of the rear wheel, we have eliminated any tendency to side draft or possibility of the plow leaving the road under severe usage.

The Ross has heavy chilled skid shoes that carry the weight of the plow and insure it moving evenly along the road surface.

The blade on the Ross has a knife edge that shears the packed snow or ice down to the pavement without undue strain on the truck.

The Ross Snow Plow is made in a variety of styles and sizes and we can furnish a plow suitable to any condition or size or style of trucks.



BURCH STONE SPREADER

Engineers unanimously agree that the spreading of stone on macadam road must be done with a proper mechanical spreader.

The process of using a Burch Spreader is to merely back the truck load of stone up to the front of the spreader and hook up draw chains from spreader. Raise the truck hoist, allowing material to flow into spreader and drive forward and the result is a smooth, even layer of material ready for the roller.

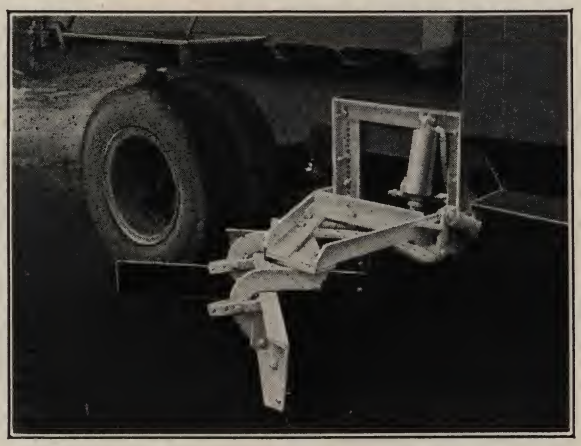
Burch Spreaders have two methods of adjustment on rear gate, or strike off, assuring that the correct amount of material will be delivered.

One method for adjusting is a set of ratchets on rear gate, while the other is for quick change of one or both ends of gate by using levers provided at each end.

Width of spread of Burch Spreaders is governed by adjustable gates at end of spreader and can be regulated to from one to two feet more than the actual width of spreader.

Burch Spreaders are equipped with an apron across front to prevent material from spilling over front, thereby causing unevenness of spread.

Burch Spreaders are made in sizes 6'6", 7'4", 8', 9' and 10'.



THE BURCH SHOULDER MAINTAINER

The Burch Shoulder Maintainer is firmly attached to side of truck chassis and fitted with one cutting and one leveling blade.

The blade operation of the Burch Shoulder Maintainer is controlled by a hydraulic hoist within the cab of the truck.

The front blade is designed to shave off high spots a distance of five feet from edge of pavement and the rear blade will distribute the loose material thus provided evenly along edge of pavement, leaving a graduated slope.

With this splendid machine a large mileage can be furnished in a short time as the truck will travel along smoothly at a reasonable speed, leaving each mile of work completed.

When not in operation blades raise and fold around close to side of truck and do not interfere with moving truck through an ordinary space.

BURCH UNDR-TRUK MAINTAINER

This machine is designed to properly and economically maintain traffic bound roads.



The Burch Maintainer is easily attached to truck by merely backing the truck into the Maintainer with rear wheels between the front and rear sections and by the use of four chains provided, the Maintainer is attached to truck in a couple of minutes and Maintainer is ready for use.

The Maintainer may be equipped with either hand wheel or hydraulic hoist and in either case the entire rigid machine is picked up and carried at a safe distance from the ground and truck can maintain a normal rate of speed to job.

The blade construction is of seven blades, set at various angles which shave the road to a positively level surface and distributes the surplus material evenly along the road, leaving no wavy or washboard effect.

With this Maintainer a large amount of road can be properly maintained in a short time, as the truck can travel at a safe working speed and leave the work completed the width of the Maintainer. One round is usually required for an ordinary secondary road.

More detailed information will be furnished on application.

BURCH PORTABLE CONVEYOR

A rugged trough type Conveyor built in lengths and widths to suit the most varying conditions.

Burch Conveyor performances cannot be excelled because they are built to eliminate the objectionable features of many other Conveyors.

High grade belts, running over concave pulleys, quick adjustment of belt, convenient and efficient lubrication, large range of adjustment as to height, widths to suit your needs and furnished with LeRoi engine power are some of the important features noted on these machines.

Write for our specifications and prices before ordering a Conveyor.



CALCIUM CHLORIDE ASSOCIATION

THE COLUMBIA ALKALI CORPORATION
Barberton, Ohio

SOLVAY SALES CORPORATION
61 Broadway, New York City

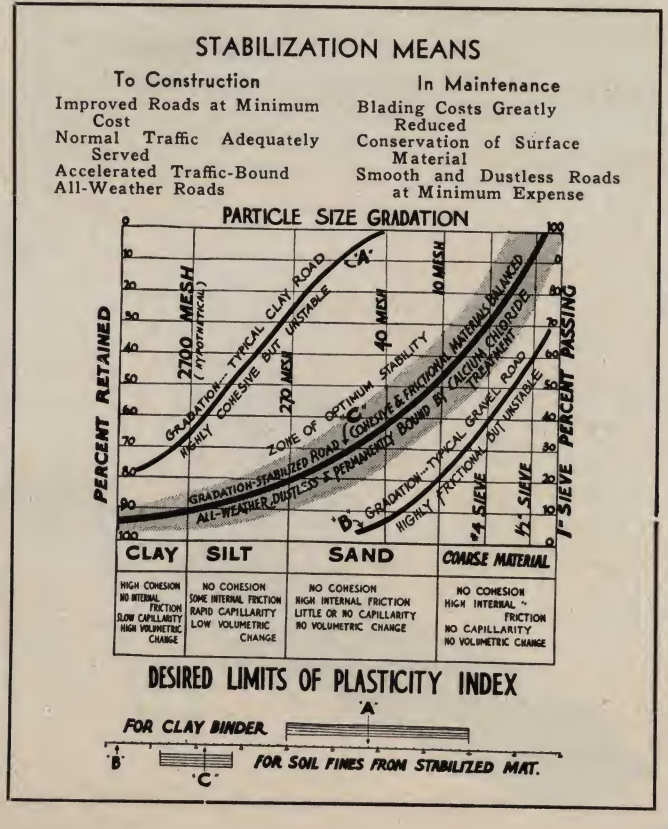
MICHIGAN ALKALI COMPANY
10 E. 40th St., New York City

THE DOW CHEMICAL COMPANY
Midland, Michigan

★ CALCIUM CHLORIDE ★

"STABILIZATION" for low-cost road surfaces

Recent discovery and application of soil science principles to control density and water permeability of natural soil aggregates, has opened a field in traffic-bound road improvement that promises to revolutionize secondary and low-cost road improvement in this country. Smooth, durable, all-weather roads highly adequate for ordinary traffic requirements and requiring greatly reduced upkeep expense are now a practical stage in highway construction. This new principle affords economic opportunity for unlimited extension of highway benefits.



Specifications:



I. The finished wearing course shall consist of a mixture of coarse aggregate, fine aggregate, natural soil binder and Calcium Chloride in proper proportions and amounts to give maximum all-weather stability.

II. (1) **Coarse Aggregate**—Comprises the portion retained on a No. 10 sieve and may consist of gravel, crushed stone or slag, or combinations thereof. In all cases 90% shall pass a sieve having ¾-inch square openings and 100% shall pass a sieve having 1-inch square openings.

(2) **Fine Aggregate**—Comprises the portion passing a No. 10 sieve and retained on a No. 270 sieve, and may consist of sand, crushed stone or slag, or combinations thereof.

(3) **Natural Soil Binder**—Shall consist primarily of fine soil particles and shall contain no stones which do not conform to the coarse aggregate requirements; also shall contain not more than 5% organic matter. Its binding properties shall be such that it provides the required physical properties to the finished mixture, as described below.

(4) **Finished Mixture**—Shall consist of coarse aggregate, fine aggregate, and natural soil binder, supplied individually or in combination, to give the following proportions:

Passing sieves: 1-inch, 100%; ¾-inch, 95%; No. 4, 55-85%; No. 10, 40-65%; No. 40, 25-50%; No. 270, 10-25%. Fraction passing No. 270 shall not be more than two-thirds of fraction passing No. 40. Fraction passing No. 40 shall have plasticity index between 6 and 14 as determined by physical test methods of U. S. Bureau of Public Roads.

(5) **Calcium Chloride**—Shall conform to requirements of American Society for Testing Materials, D98-30T.

(6) **Quantities** of pit-run gravel, stone, slag, soil binder, etc., required to give finished mixture described above shall be determined by laboratory tests on the supplies of materials available and shall be specified in cubic yards or tons per mile of road.

For soil survey and analysis service the Calcium Chloride Association and its members invite your inquiry at no obligation.

FOR DUST CONTROL

For general gravel road maintenance the application of Calcium Chloride is extremely simple—through an inexpensive spreader drawn by motor truck. Approximately 2½ lbs. of Calcium Chloride per square yard per season, generally in three applications of diminishing quantities, are sufficient to afford dustless and economical upkeep.



FOR PARKS, PLAYGROUNDS

public parking spaces, tennis courts, baseball diamonds, cemeteries, private estates and drives, etc., Calcium Chloride is a most effective surface treatment, for which small hand-operated wheel spreaders are available.

FOR ICE CONTROL

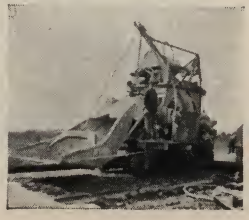


Mixed with coarse sand, cinders or fine gravel, and applied to dangerous, icy street intersections, curves and hills, Calcium Chloride affords unequaled traffic safety. It imbeds the grit material into the ice and provides tractive surface to prevent skidding. May be applied either with shovels or mechanical spreader. Or, stock piles of grit materials may be treated with Calcium Chloride in advance of cold weather —which keeps them from freezing and permits easy handling. Treatment: About 50 lbs. of Calcium Chloride per cubic yard in stock piles and an additional 50 lbs. at time of application. Use either in flake form or in solution. Its capacity for melting ice at sub-zero temperatures makes Calcium Chloride highly effective for "de-icing" paved streets and sidewalks, thawing out hydrants, street drains, catch basins; loosening manhole covers; breaking up ice jams and protecting bridge piers.



FOR CONCRETE CURING

Calcium Chloride is a positive, complete, time-saving, cost-cutting, concrete curing agent. Supplies and retains the necessary moisture for full hydration of cement. Requires no prolonged field control; no costly and troublesome providing and removal of cover materials; no piping of water supply and daily wetting. Calcium Chloride may be used integrally (incorporated with the mix as part of the gauge water) or by surface application to the finished concrete. With the latter one man with a simple spreader can, in a few hours, cover all the concrete the paver can lay in a day. As with other methods, twenty-four hours of wet burlap is recommended. Calcium Chloride offers the only concrete curing method that assures high early strength (greater than by wet earth by fully 30% at 48 hours) and permits early opening of pavement to traffic without interrupting the curing process. Eliminates long use of bumpy detours; permits quick clean-up and release of equipment. Calcium Chloride concrete curing is approved by U. S. Bureau of Public Roads; and many states now specify or permit its use.





FOR BUILDING CONSTRUCTION

Calcium Chloride provides a more plastic mix; accelerates rate of hardening; permits earlier finishing and release of forms, gives higher strength concrete. The only method that provides inherent continuous supply of moisture necessary to complete hydration of cement.

FOR COLD-WEATHER CONCRETING

Calcium Chloride lengthens the construction season. Minimizes freezing danger; accelerates rate of hardening; speeds work; shortens time requiring cold-weather precautions; reduces loss of strength ordinarily occurring n sub-normal (below 70°) working temperatures.

PACKING

Flake Calcium Chloride is shipped in easily handled, moisture-proof bags of 100 lbs. net; also in steel drums of 400 lbs. net.

FREE BOOKLETS, ETC.

Any of the four firms listed on opposite page will gladly furnish complete information covering Calcium Chloride's uses for any of the purposes mentioned above.

THE PHILIP CAREY COMPANY

LOCKLAND, CINCINNATI, OHIO

Established 1873

BRANCHES AND DISTRIBUTORS IN PRINCIPAL CITIES

Manufacturers of Asphalt, Asbestos and Magnesia Products, Roofings, Shingles, Waterproofing Materials, Heat Insulation, Etc.

PRODUCTS: Elastite Expansion Joint, Elastite Asphalt Plank, Elastite Rail Filler, Elastite Subgrade Felt

Carey Elastite Expansion Joint



Carey Elastite EXPANSION JOINT

Is used in concrete roads and streets and in other monolithic concrete construction to prevent damage to the work due to expansion and contraction. It is composed of two substantial sheets of asphalt-saturated felt between which is "sandwiched" under pressure a heavy body of special asphaltic compound.

Elastite Expansion Joint has for 20 years been the standard expansion joint. It is stiff and strong and keeps its shape in any weather. Easy to use, free from breakage and loss, economical in service. It is relied upon by the road-building industry and has been used extensively in important work all over the world.

Elastite Expansion Joint is made in a variety of thicknesses, in any width up to 36 inches. Lengths 5 feet to 10 feet are standard, but longer pieces can be supplied, limited only by convenience of handling.

We will gladly supply you with samples, prices and descriptive literature.

Carey Elastite Asphalt Plank

Originated by us in 1925, is a dense, hard, tough composition of asphalt, fibre and mineral, formed under pressure into planks of various thicknesses and widths. It is unlike any other paving material, and when properly laid upon a suitable base will resist the action of heavy traffic to an almost unbelievable degree. Millions of square feet of Elastite Asphalt Plank are in service on highway bridge floors throughout the United States and Canada.

Elastite Asphalt Plank has no grain and does not swell or shrink. It is non-absorptive and proof against decay.

Elastite Asphalt Plank may be applied over wood, concrete, or any other suitably smooth substantial surface, by common labor using ordinary tools. Over a wood deck it is spiked down with ordinary nails or spikes, and upon concrete it is cemented in place with asphalt.

Elastite Asphalt Plank is made in a wide range of sizes to meet every requirement, and prompt shipments can be made in any quantity.

Send for samples, prices and descriptive literature.





State Highway Bridge over the Missouri River at Boonville, Mo., 18 ft. wide by 2,163 ft. long. Elastite Asphalt Plank, 1½ inches thick, was installed May, 1928.

A time-saver and a real tool for the practicing engineer—

HAND BOOK of COST DATA

by

H. P. GILLETTE



This practical tool presents unit costs in great detail accompanied by statements as to conditions. This makes the book not only invaluable in estimating but in reducing costs of construction, both for the *engineer* who designs and the *contractor* who executes.

Actual records are shown with the detailed cost during various classes of work. Valuable data on methods of construction are given, thus enabling the contractor or the superintendent to handle the work in the most economical manner. The data on any question which demands costs can be found in this book.

The true value of this workbook can be realized only through its use in actual work. Send for your copy today and increase your store of knowledge.

TABLE OF CONTENTS

SECTIONS. I.—Principles of Engineering Economics and Cost Keeping. II.—Earth Excavation. III.—Rock Excavation. Quarrying and Crushing. IV.—Roads, Pavements and Walks. V.—Stone Masonry. VI.—Concrete and Reinforced Concrete Construction. VII.—Water Works. VIII.—Sewers. IX.—Timber Work. X.—Buildings. XI.—Railways. XII.—Bridges and Culverts. XIII.—Steel and Iron Construction. XIV.—Engineering and Surveys. XV.—Miscellaneous Cost Data.

Price $6.00

Ten Days' Free Examination

USE ORDER CARD NO. 2
on Page 137
when requesting your copy of this book.

GILLETTE PUBLISHING CO.
400 W. Madison St. Chicago, Ill.

C. H. & E. MANUFACTURING CO., Inc.

120 E. Mineral St., Milwaukee, Wis.

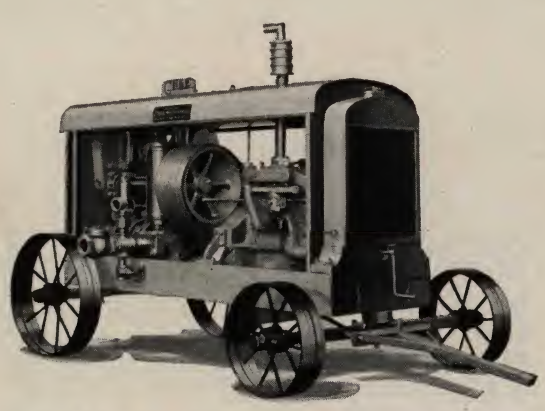
CONTRACTORS' EQUIPMENT

Diaphragm Pumps: 4″ Single or Double. Horizontal or Vertical type engines. Capacity—single, 8,000 g.p.m.; double, 12,000 g.p.m.

Centrifugal Pumps: "Self-Priming" 4 sizes—2, 3, 4 and 6″ Suction and discharge. Self-Priming and easily portable.

Sewage and Trash Pumps: 4 sizes—3, 4, 5 and 6″ Suction and Discharge. Will not clog. No foot valve needed.

Triplex Force Pumps: 3 sizes. 40 to 125 g.p.m. Maximum pressure of 500 pounds.



C. H. & E. No. 11 Triplex Road Pump with Texrope "V" Belt Drive, between engine and pump.

Saw Rigs: 4 sizes. Ripping capacity 2″ to 6″ lumber. Stationary and tilting arbors. Also band saw, jointer and mortising attachments.

Hoists: 10 sizes. Capacities from 500 to 6,000 lbs. Single and Double Drum, and Reversible Outfits.

Mortar Mixers: 2 sizes. No. 5 capacity for 40 bricklayers. No. 6 capacity for 70 bricklayers.

Material Elevators: Single and Double cage for handling brick and mortar.

Ditchers: Little Goldigger Model "A" for conduits, pipelines and drainage work. Maximum width 6″, depth 48″. Hydraulic boom, 2 speeds forward and 2 speeds reverse.

Write for complete catalog.

CHICAGO TUBING & BRAIDING CO.

1315 South Third Ave., Maywood, Ill.

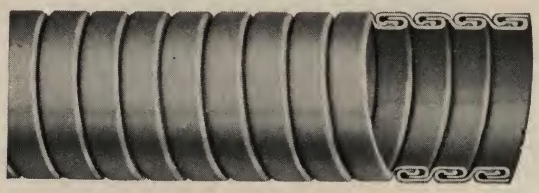
SALES OFFICES:

DALLAS, TEXAS. C. B. Hasford, P. O. Box 88.
NEW ORLEANS, LA. Sidney Farrar, 1307 Arabella St.
CLEVELAND, OHIO. 1122 Fidelity Bldg., 1940 E. 6th St.
DETROIT, MICH. Service Steel Company, 1435 Franklin St.
PITTSBURGH, PA. 1711 Investment Bldg., Fourth Ave.
BOSTON, MASS. Fred L. O'Conner, 49 Federal St.
ST. PAUL, MINN. G. A. Ashton Co., Inc., 1547 University Ave.
SAN FRANCISCO, CAL. R. W. Gould, Inc., Box 344.
HOUSTON, TEXAS. The W. H. Steigerwald Co., Inc.

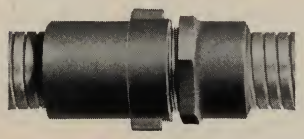
PRODUCTS: Rex-Tube Flexible Metal Tubing and Couplings.

Uses: Rex-Tube Flexible Tubing is suitable for use whereever a flexible hose is required. It is especially adapted for rough handling, pressures, and hot materials, which limit and shorten the life of less sturdy tubing. It is used for the conducting of steam, water, air, gas, hot tar, hot asphalt, creosote, grease, oil fats, shavings, chips, filings; as conduit for wires and cables; for heater, carburetor and exhaust tubes; and many other purposes. In road work it is used on the following equipment:

Asphalt Kettles
Concrete Heating Units
Tank Car Heaters
Tar and Oil Distributors
Oil Burners and Heaters
Oil and Gasoline Engines
Kerosene Torches
Oil Lines
Concrete Mixers
Pressure Distributors
Pneumatic Tools
Road Oilers
Compressors
Tank Car Unloading
Sprayers



R T 15 Flexible Galvanized Steel Tank Car Unloading Tubing: Rex-Tube Flexible Steel Tubing is ideally suited for unloading gasoline, oils, fats, greases, tar, asphalt, creosote, etc., from tank cars. Rex-Tube Flexible Tubing is easily moved over a considerable distance, therefore, it is not necessary to take the extra time and trouble to exactly spot the car. R T 15 Flexible Tubing is made to U. S. Navy specifications. Write for Bulletin No. 51.



Soldered Coupling: For R T 15. Flexible Tubing suitable for use where temperatures are below melting point of solder.



Elbow Tank Car Unloading Coupling: Elbow Tank Car Unloading Couplings have a 45° angle which permits a natural unobstructed flow from the car without undue strain on the tubing. Fits standard tank-car outlets.

Rex-Tube Steam and Oil Tubing: R T 15 Steel Tubing is ideal for high pressure work where corrosion is not apt to occur. Where materials and conditions are conducive to corrosion of steel, bronze tubing is recommended.



R T 20 Flexible Metal Tubing is the same as the R T 15 except that it has a braided metal covering, either galvanized steel or phosphor bronze. In sizes from ½" I.D., and up, the metal braiding is covered with an outside spiral wire armor to protect the braiding when the tubing is dragged over rough surfaces. R T 20 Flexible Tubing is suited for all around high pressure hard service, for conveying hot oils, tars, superheated steam and air under the most strenuous working conditions.

Couplings for R T 15 and R T 20 Flexible Tubing: Couplings are made in three styles, Soldered, No. 1 Packed, and No. 2 Packed.

Soldered couplings for both styles of tubing are suitable for general use where the temperatures are not over the melting point of solder (300° F.). No. 1 Packed Couplings are made for uses involving higher temperatures and high pressures. No. 2 Packed Couplings are made with a larger shank to permit the attachment of a handle or shield to prevent the operator's hands from coming in contact with the hot tubing. Write for Bulletin No. 51.

Square Lock Metal Tubing: This is the most flexible type of metal tubing, suitable for low pressure, light service conduit. It is made in steel, brass, bronze and aluminum. **R T 3 Asbestos Packed** for carburetors and low pressure oil. **R T 2 Cord Packed** for cores of gasoline and oil hose, air hose, gravity pressure tubes and wire conduits. **R T 1 Unpacked** for wire conduits, used where light but strong casing is desired, protects wires from chafing which causes "shorts" or "grounds." Write for Bulletin No. 31.



Rex-Tube Flexible Exhaust Tubing: Made from heavy metal in the four wall Interlocking construction, **R T 8 Unpacked** is for exhaust use on heavy duty trucks and tractors; **R T 9 Asbestos Packed** is for heavy exhaust work. Packing of high grade asbestos prevents any possible escape of gas. Suitable for Exhaust lines indoors. **R T 10 Copper Packed** is for heavy exhaust work at high temperatures. Write for Bulletin No. 51.

Rex-Tube Service: Thirty-two years of experience in flexible tubing manufacturing; thorough testing of all products; full line of sizes available for shipment at all times.

LOW COST ROADS AND BRIDGES

Authoritative — Complete

by

V. J. BROWN, C. E.
Editor — Roads and Streets, Assoc. Mem. Am. Soc. C. E., Mem. Western Soc. Engr., Mem. Am. Road Bldrs. Assn.

C. N. CONNER, B. S. in C. E.
Engr. Exec., Am. Road Bldrs. Assn., Mem. Am. Soc. C. E., Mem. Am. Soc. Testing Mtls., Com. Chmn. on Low Cost Roads of Highway Research Board.



This vital treatise on the question of low cost, economical roads and bridges is the latest word on the subject. The text was checked by leaders, chemists and engineers for technical accuracy. As you will note from a glance at the Summary of Chapters below, there is a wide range of treatment accorded this subject and everyone concerned with road and bridge building will find a wealth of up-to-the-minute information that is authoritatively presented.

Chapter V alone is worth ten times the price of the book if it is used but once. Nowhere else will be found a collection of information on bituminous construction types to compare with the detailed discussions of tar and asphalt roads as presented herein. This book fills a need. It can be read by the layman.

Low Cost Roads and Bridges belongs in your library. You will find its first reading profitable and as a frequent source of reference it should prove invaluable.

Voluminously Illustrated.

TABLE OF CONTENTS

I.—Design of Local Highways. II.—Economics and Planning. III.—Location, Design, and Grading. IV.—Untreated Surfaces. V.—Bituminous Surface Courses. VI.—Use of Concrete for Low Cost Roads. VII.—Materials and Proprietary Mixes. VIII.—Interpretation of Tests. IX.—Equipment and Machinery. X.—Maintenance. XI.—Low Cost Bridges and Culverts.

Ten Days' Free Examination

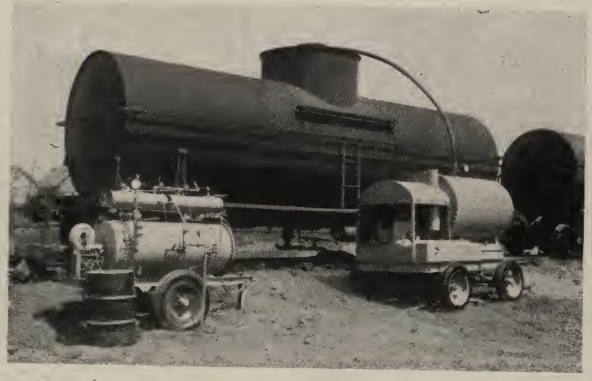
USE ORDER CARD NO. 6
on Page 137
when requesting your copy of this book.

GILLETTE PUBLISHING CO.
400 W. Madison St. Chicago, Ill.

CLEAVER-BROOKS CO.

MILWAUKEE, WISCONSIN

Portable Tank Car Heaters and Boosters!



This ONE-CAR Heater is raising heavy tar from 60° to pumpable temperature of 170°. The Cleaver pumping booster is shown heating the same tar from pumping temperature to application temperature of 375°. When materials arrive at pumpable temperatures, the ONE-CAR Heater is unnecessary.

Cleaver Tank Car Heaters and Boosters have solved the problem of heating bituminous materials shipped in railroad tank cars . . . they are a distinct advancement over any other method ever employed to heat bituminous materials to both pumpable and application temperatures.

Cleaver Tank Car Heaters are portable units, mounted on both trailers and trucks. . . . They are built in four sizes with steaming capacities from one to four cars. They are ideally suited to uses such as heating tank cars of bituminous materials. . . . Thawing culverts and manholes . . . steam cleaning machinery and trucks.

All Cleaver Heaters are designed simply and compactly constructed. . . . They are built to render dependable service with the minimum of care and attention. . . . They are designed to effect economy in time, operation and transportation costs.

Cleaver Heaters offer these outstanding advantages: Rapid Steaming—High Efficiency—Portability—Low Fuel Costs—Saving Wasted Condensate—Rapid Heating—Low Maintenance Costs—Controlled Heating Capacity.

Let us send you bulletin which thoroughly describes and illustrates Cleaver Tank Car Heaters. Write today.

CLEAVER

TANK CAR HEATERS AND BOOSTERS

not all Crawler tractors are CLETRACS

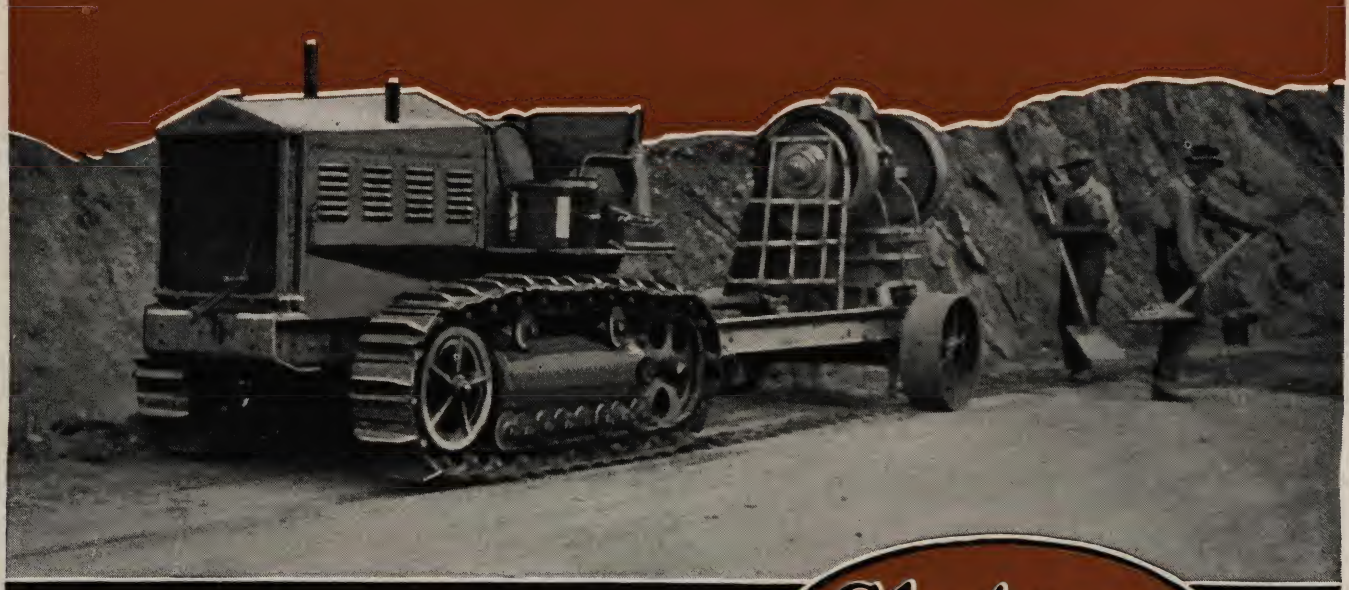
. . . those are which cut road repair costs

. . . In resurfacing an important Colorado highway, a saving of approximately 80% over conventional methods was made by the Cletrac shown below. A full crew of men were employed for the entire season.

The Cletrac with rock crusher operated from the power take-off, furnished crushed stone *on the job* from rocks and boulders taken from the gutter. A cost-reducing record difficult to equal—together with a full season's work for a six-man crew. Other equally impressive records of economy are made possible by Cletrac's amazing flexibility, adaptability and versatility. Write today.

Better be safe than sorry. See what Cletrac gives before you buy. We make crawler tractors exclusively; Model 80, the world's most powerful automotive unit, and models with horsepower rating 55, 35, 25, 20.

THE CLEVELAND TRACTOR COMPANY, CLEVELAND, OHIO, U. S. A.



Cletrac
Crawler Tractors
Built To Endure

Cletrac DIESEL



Cletrac
Crawler Tractors
Built To Endure

THE CLETRAC 80, world's most powerful automotive unit, is now offered to the construction industry, powered with a Diesel motor of advanced design, developing 85 drawbar horsepower in second gear. • By standardizing on Cletracs, the crawler tractor buyer may now secure machines of similar construction and operating requirements with the type of power best adapted to his particular job . . . He may select—The Cletrac 80, Diesel Powered, in cases where the fuel economy of a Diesel motor outweighs other considerations. • The Cletrac 80, Gasoline Powered, in cases where proved operating efficiency and low maintenance costs are the measure of performance. • Thus Cletrac, by providing tractors powered according to the needs of the user, again establishes new standards of service to the construction industry. . . For details consult Cletrac distributors.

THE CLEVELAND TRACTOR COMPANY
CLEVELAND, OHIO, U. S. A.

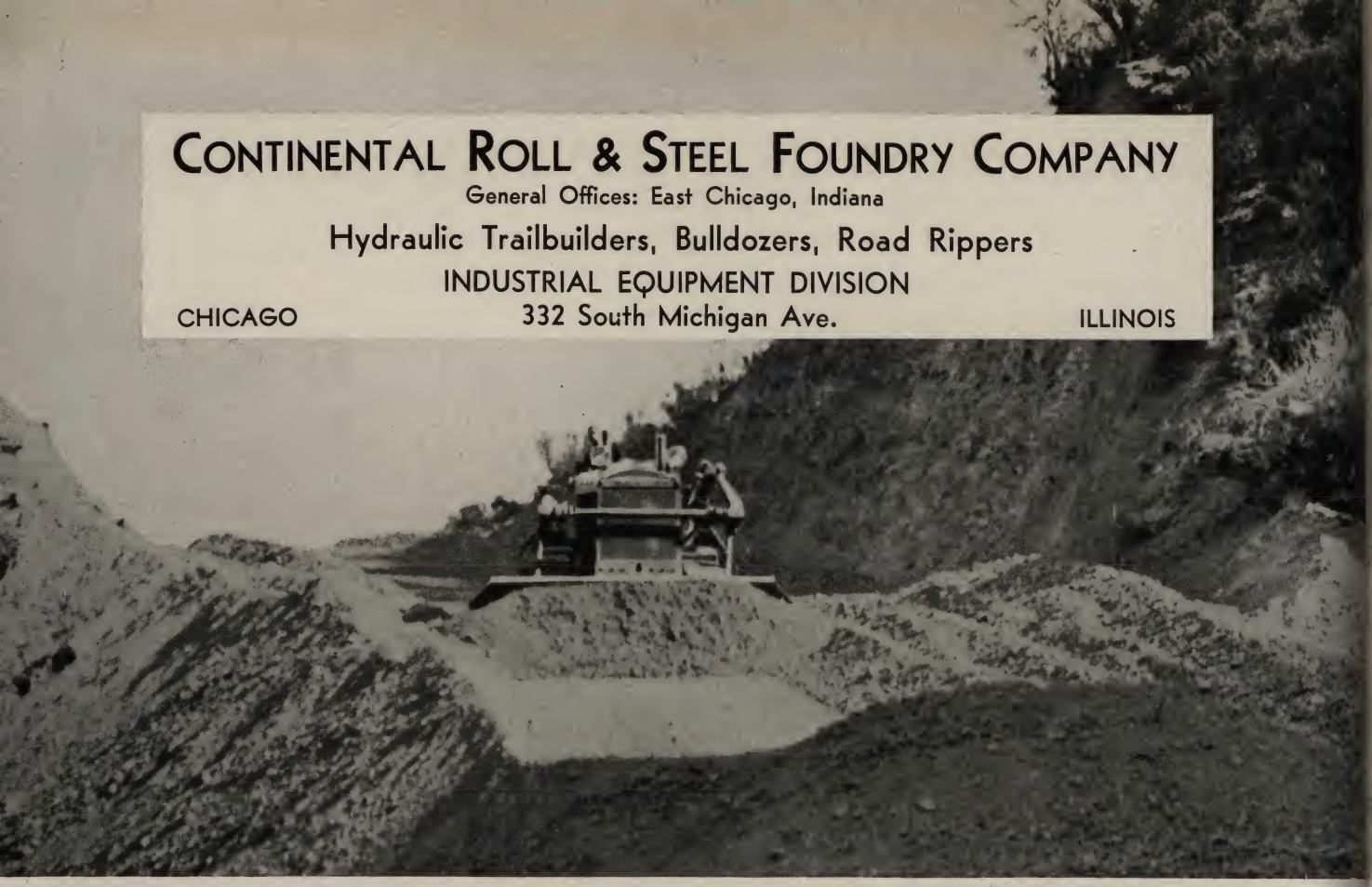
CONTINENTAL ROLL & STEEL FOUNDRY COMPANY

General Offices: East Chicago, Indiana

Hydraulic Trailbuilders, Bulldozers, Road Rippers

INDUSTRIAL EQUIPMENT DIVISION

CHICAGO 332 South Michigan Ave. ILLINOIS

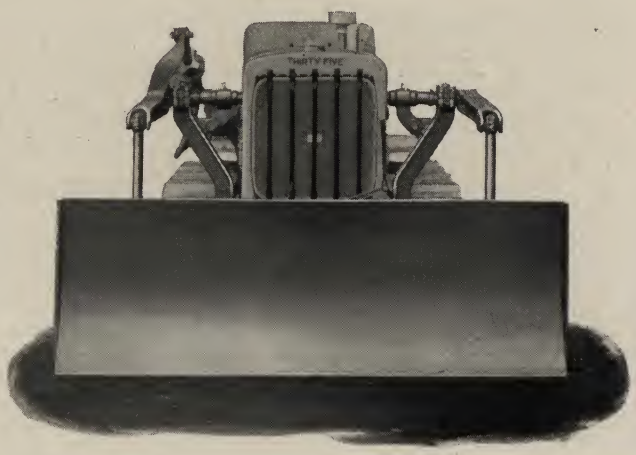


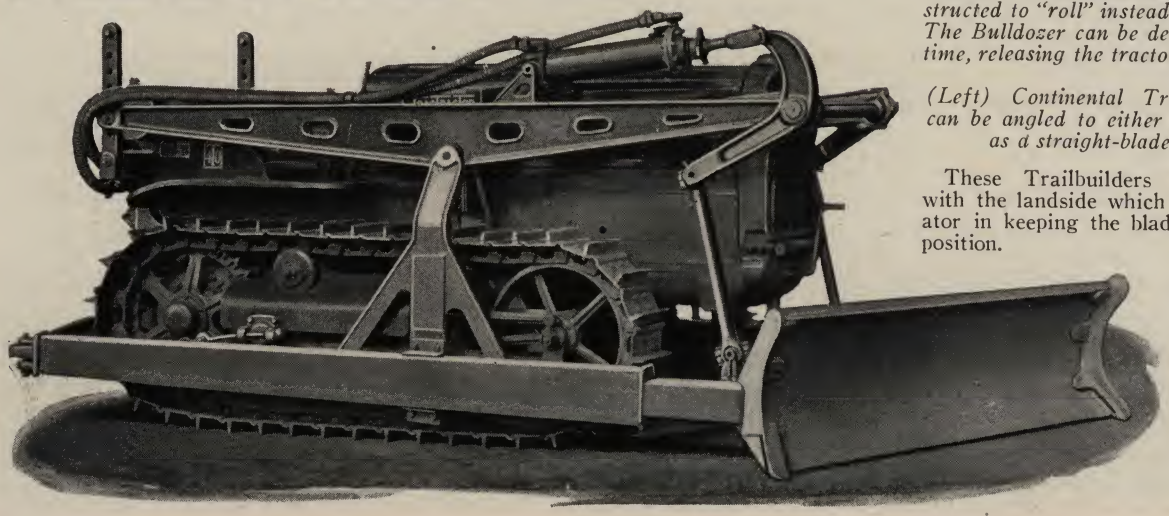
Continental equipment is built for Allis-Chalmers, Caterpillar, Cletrac and McCormick-Deering tractors.

Continental-Built Woolridge Trailbuilders and Bulldozers are establishing distinctive records in construction work of all kinds. Many are in pioneer mountain road work and others opening trails through dense forests; and large numbers are on highway and municipal work throughout the country. They are rugged earth and rock moving units that stand up under the most abusive punishment. The blades are hydraulically powered both up and down and can be held in any position so the operator can utilize the weight of the tractor in maneuvering the blade if necessary. The trailbuilder blade can be readily angled in any vertical position, enabling the operator to build a uniform grade on any slope.

Constructed of Dynamic Steel

Continental-Built equipment is constructed of Dynamic Steel, a new metallurgical development in steel alloys. This new steel has exceptional ability to withstand the tremendous and continuous shock to which this equipment is subjected.





(Above) Continental Bulldozers are constructed to "roll" instead of push the dirt. The Bulldozer can be detached in a short time, releasing the tractor for other work.

(Left) Continental Trailbuilder blades can be angled to either side or operated as a straight-blade bulldozer.

These Trailbuilders are constructed with the landside which assists the operator in keeping the blade and tractor in position.

CURTIS PNEUMATIC MACHINERY COMPANY

EXECUTIVE OFFICE

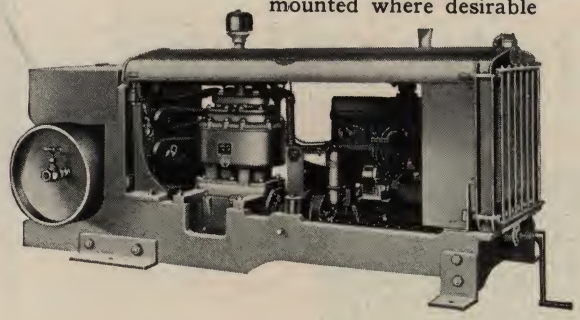
1913 Kienlen Ave., St. Louis, Missouri

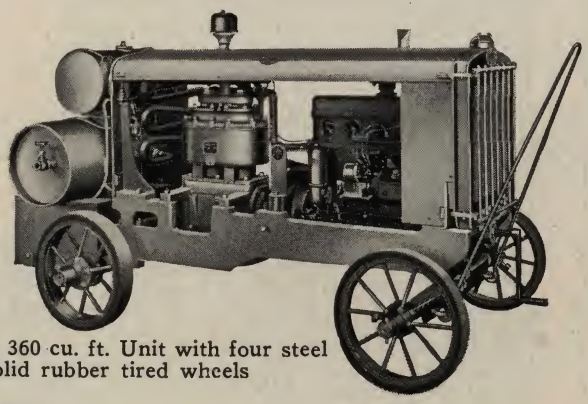
Air Compressors, Hoists, Cranes, Trolleys

New York Office, 518-B Hudson Terminal

Pacific Coast, 310 4th St., San Francisco, Cal., Ed Crowley, Repr.

All portable units may be skid mounted where desirable





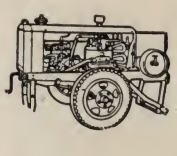
40 to 360 cu. ft. Unit with four steel or solid rubber tired wheels

Products of Experience

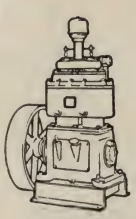
In any purchase, your real protection is the reputation, experience and financial standing of the manufacturer.

The Curtis 20½-acre plant, its modern equipment and latest production methods used, backed by ample financial resources, are some of the factors responsible for the continued growth and success of the Curtis Company for 80 years. Strong financial background must be behind a product. Experience and ability alone do not suffice.

Curtis Compressors

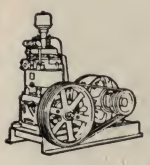


In its new model "C" 2- and 4-cylinder Curtis Compressors, Curtis provides carbon-free valves, Timken bearings and centro-ring oiling.



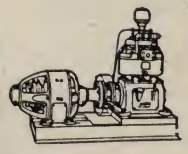
In perfecting practically **carbon-free valves,** Curtis engineers have solved a big problem of compressor operation, portables particularly.

New type head with short intake passages, oversize ports and straight line air flow—brings air into cylinder at lowest possible temperature, with resulting peak pressure and temperature of compression so low that there is practically no evaporation of oil on piston and cylinder walls.



Cooled-air intake also greatly increases capacity of compressor.

Timken bearings assure longer life with easy adjustment. **Centro-ring oiling** provides controlled lubrication.



Entire design increases capacity in relation to size so that prices are relatively lower. Compressor only or motor-driven units, 3 to 50 HP.

Curtis Portables

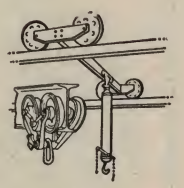
Portable type provided in 40 to 360 cu. ft. unit with four steel or solid rubber tired wheels—also 40 and 66 cu. ft. 2-wheel units with pneumatic tires. All portable units may be skid mounted where desirable.

Curtis Air Hoists



Cost one-fifth that of other power hoists and practically no more than a chain block. Can be handled by ordinary labor—no costly production interruption from hoist failure. Proof against destructive atmospheric conditions. One-half to 10-ton capacities.

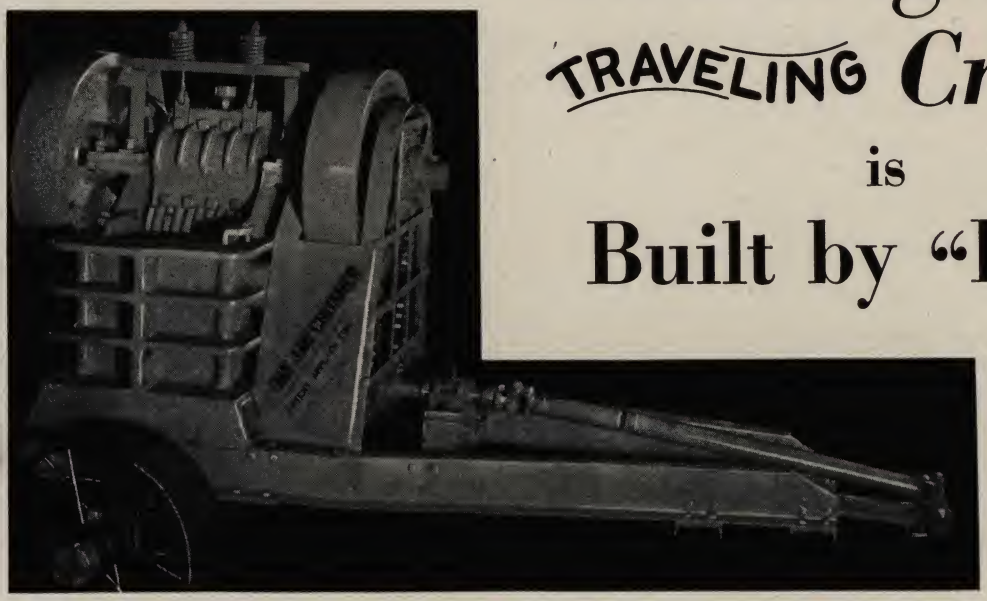
Curtis Cranes and Trolleys



Curtis I-Beam Crane has 10 to 40-foot span and ½ to 10-ton capacity. Flexible roller bearing, easily handled. Handles heavy loads swiftly, gently, and very accurately. Original cost low and maintenance negligible.

Curtis I-Beam Trolley has large wheels, flexible roller bearings, self-equalizing frame and other features to make it unusually easy running.

The *Original* TRAVELING *Crusher* is Built by "DAY"



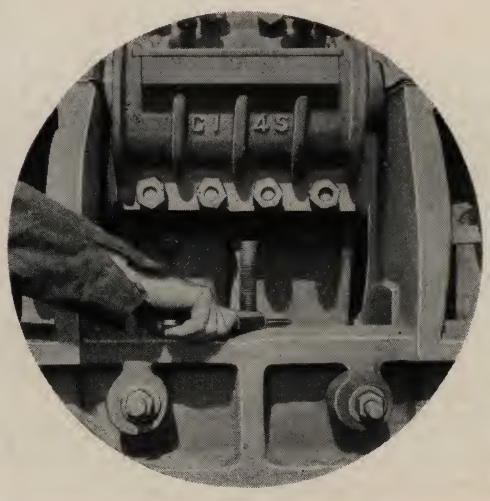
All Steel . . . Forced Feed . . . Jaw Type . . . Every Part Built Oversize. If you build macadam roads, you cannot afford to be without the DAY — THE ORIGINAL TRAVELING CRUSHER.

The DAY Traveling Crusher is Tractor-Drawn and operated. Made for use with any of the leading "Track-Type" Tractors, equipped with A. S. A. E. Rear Power Take-Off, such as . . . Caterpillar, Cletrac, Monarch or TracTracTor. The DAY is the only crusher made for direct rear power take-off use with the above tractors. You may detach the DAY Crusher in two minutes, should tractor be desired for other work.

This Traveling Crusher has saved from Thirty to Fifty percent in building and maintaining macadam roads and trails. They are used by Contractors, Counties, States and the Federal Government throughout the country. Let us send you the complete story. No obligation—of course—on your part.

Capacity and Specifications

Feed Opening	9 in. x 16 in.
Capacity (Tons per 10-hour day, 3-in. materials and under)	100 to 150
Capacity (Tons per 10-hour day, 1½-in. materials and under)	80 to 120
Capacity (Tons per 10-hour day, ¾-in. materials and under)	50 to 80
Main Frame, or Crusher Base	Made of Steel, Heavily Ribbed
Jaw Plates—Reversible	Manganese Steel
Speed of Crusher in R. P. M.	275
Power Required (Belt)	15 to 20 H.P. or any "Track Type" Tractor equipped with Rear A. S. A. E. Power Take-Off, capable of producing 20 H.P. or more.
Approximate Weight on Skids	5,500 lbs.
Approximate Weight Mounted, Complete, on 2-wheel truck	7,200 lbs.
Diameter of Shafting at Eccentric	5-1/16 in.
Diameter of Shafting at Side Bearings	4-3/16 in.
Length of Eccentric Bearing	15 in.
Length of Side Bearings	8¾ in.
Diameter of Fly Wheel	30 in.
Width of Fly Wheel Face	7 in.
Shaft	Special Alloy Steel, High Quality



Quick Adjustments While Operating

Ease of adjustment is a noteworthy point. Even while the machine is in operation a few turns on the bolt (as illustrated) change the position of the wedges and reduce or increase the size of material as desired. You get an exceptionally uniform product with the **DAY**—always.



DAY PULVERIZER CO., Inc.

FACTORY AND MAIN OFFICE — KNOXVILLE, TENNESSEE

Representatives and Distributors in Principal Cities

THE EAGLE-PICHER LEAD COMPANY

Manufacturers of Lead Pigments for Paints

GENERAL OFFICES

Temple Bar Building, CINCINNATI, OHIO

Eagle Sublimed Blue Lead—for Bridges and Other Metal Surfaces

Sublimed Blue Lead (Basic Sulphate of Lead, Blue) is a fine, slate-gray powder, produced by sublimating galena ore (lead sulphide) in special furnaces. The pigment is accurately mixed with linseed oil in proper proportions and ground. No other raw materials are used. Sublimed Blue Lead is not only highly efficient for rustproofing, but is also economical, both in original cost and long service.

A gallon of Sublimed Blue Lead will cover six hundred to eight hundred square feet of metal of average smoothness.

Advantages of Sublimed Blue Lead—

Proper basicity, chemically stops corrosion.
Exceptional durability; does not crack, check or peel.
Elasticity and toughness in oil.
Extreme fineness and smoothness.
Easy brushing, spraying, and dipping qualities, air dried or baked.
Remarkable opacity.
Pleasing color—being slate gray and easily tinted.
Exceptionally low cost per square foot.
Can be used with neutral treated oils and varnishes.
Suitable for use on wood or metal—all coats.

Estimating Paint Requirements on Structural Steel

The scale below represents a method employed by an important steel fabricator for rapidly estimating the approximate paint requirements of large projects. Based upon the use of Sublimed Blue Lead, which as a priming coat covers from six hundred to eight hundred square feet per gallon, this chart expresses the gallons of paint required per ton of steel in various types and shapes:

Average Highway Bridges	0.4 gal. per ton
Highway Beam Spans and Lattice Railing	0.8 gal. per ton
Plate Girders, Highway or Railway	0.24 gal. per ton
Heavy Truss Spans, Highway or Railway	0.32 gal. per ton
Railway Beam Bridges	0.2 gal. per ton
Light Mill Building	0.4 gal. per ton
Heavy Mill Building	0.32 gal. per ton
Office Buildings	0.2 gal. per ton

For estimating graphite or iron oxide paint requirements, *add* 25% *more* paint to the scale above. For estimating red lead requirements, *add* 50% *more* paint to the scale.

How to Use Sublimed Blue Lead—The removal of rust, mill scale and dirt should be done generally by sand blasting or through the use of metal brushes, scrapers, chisels, hammers or other effective means until bright steel is exposed. If sand blasting is used, the first coat of paint must follow immediately.

Oil and grease may be removed by the use of gasoline or benzine. Do not apply paint on wet or damp surfaces and in no case until preceding coat is dry and hard. Allow two to four days before applying second coat for exterior work. For interior work allow one week before applying a second coat, and twenty-four hours between second and third coats.

Paint shall be evenly spread and shall be thoroughly brushed out. Where solder fluids have been used on metal surfaces, it shall be cleaned thoroughly with benzine before any paint is applied. All rivet heads and bolts, and all edges and corners shall be thoroughly covered with paint in painting structural steel or other metal work.

How to Secure Sublimed Blue Lead—Sublimed Blue Lead in Oil sells at the same low price as Eagle White Lead in Oil and may be had in 12½, 25, 50 and 100-lb. containers, or may be secured from a reliable paint manufacturer by specifying pure Eagle Sublimed Blue Lead mixed to paint consistency ready to apply.



Lorain Central Bridge, Cleveland, Ohio. Steel protected against moisture, gases and corrosion by Eagle Sublimed Blue Lead.

Paint Formulæ

Sublimed Blue Lead in Oil (paste)—First Coat

Sublimed Blue Lead in Oil	100 lbs.
Raw Linseed Oil	2⅜ gals.
Turpentine	1¾ gals.
Drier (unadulterated and rosin free)	1 qt.

Paint produced approximately 7¼ gallons weighing 17½ to 18½ lbs. per gal.

Second Coat

Sublimed Blue Lead in Oil	100 lbs.
Raw Linseed Oil	3 gals.
Turpentine	2 qts.
Drier (unadulterated and rosin free)	1 qt.

Paint produced approximately 6⅔ gallons weighing 18½ to 19½ lbs. per gal.

Sublimed Blue Lead—Dry (powder)—First Coat

Sublimed Blue Lead—Dry	90 lbs.
Raw Linseed Oil	3⅔ gals.
Turpentine	1¾ gals.
Drier (unadulterated and rosin free)	1 qt.

Paint produced approximately 7¼ gallons weighing 17½ to 18½ lbs. per gal.

*Second Coat

Sublimed Blue Lead—Dry	90 lbs.
Raw Linseed Oil	4¼ gals.
Turpentine	2 qts.
Drier (unadulterated and rosin free)	1 qt.

Paint produced approximately 6⅔ gallons weighing 18½ to 19½ lbs. per gal.

*Where impractical to have two formulæ used on a job, this second coat formulæ is suitable for both first and second coats.

The Raw Linseed Oil shall conform to the linseed oil specifications of the A.S.T.M. Standards, Pages 655-658, Volume 21.

Note: For painting metal surfaces, where a temperature not to exceed 350° to 400° Fahrenheit is maintained, you may substitute winter pressed fish oil for Linseed oil.

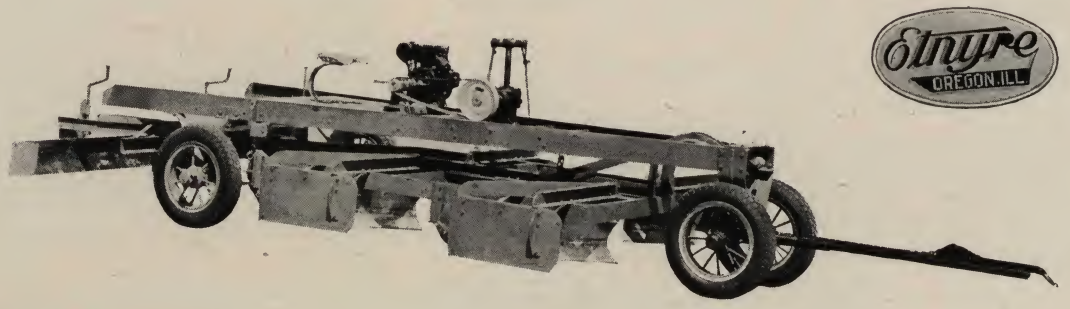
Eagle Red Lead—Dry and in Oil

Eagle Red Lead in Oil is packed in 100, 50, 25, and 12½-lb. kegs. In dry form, it is put up in barrels of 500-600 lbs.

It possesses high "true" red lead content and is fine enough to insure splendid brushing qualities. It is impervious to water and unaffected by atmospheric gases. The rapid drying qualities of Eagle Red Lead make it decidedly advantageous for use where a hard surface, capable of withstanding abrasion, must be produced in a shorter time than usual.

E. D. ETNYRE & COMPANY

OREGON, ILLINOIS, U. S. A.



Model RM-2 Retread Mixer

The Model RM-2 Retread Mixer shown above is a new development in mixed-in-place equipment. An important feature of this machine is that it is equipped with a power lift to raise the blades.

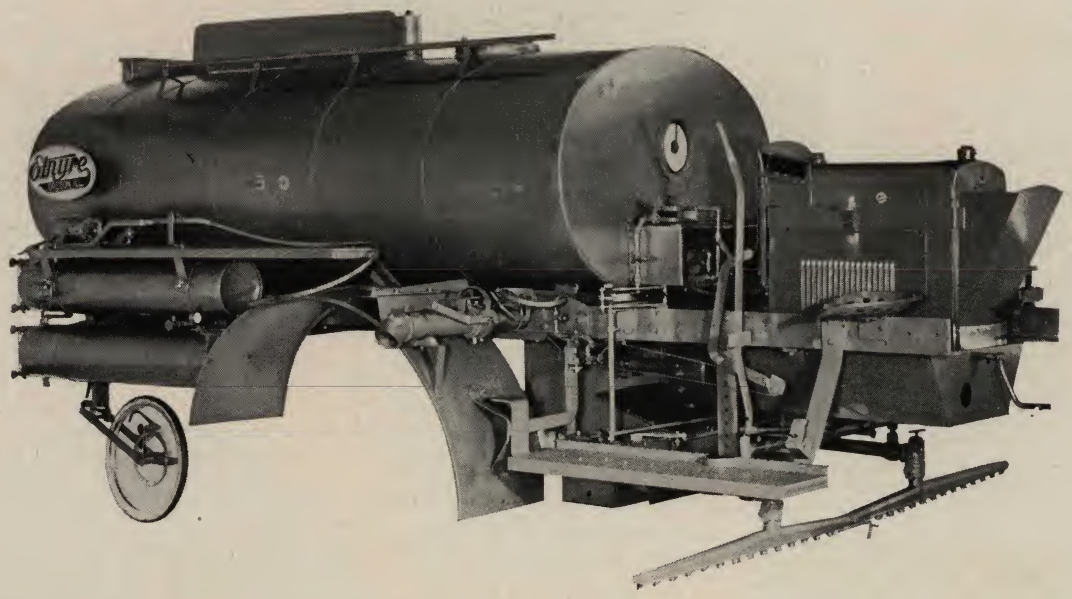
Material is mixed five times and then leveled in one trip, thereby saving time and expense. Complete descriptive matter will be gladly furnished on request.

Models E and EJ Street Flushers

A model and size of street flusher for the particular requirements of any town and city. Furnished for mounting upon motor trucks, or with semi-trailers for use with motor truck tractors and industrial tractors.

Street flushers furnished with auxiliary equipment for street sprinkling, fire fighting, sewer flushing, sidewalk cleaning, pumping out flooded basements, etc.

Write for more complete information on the most modern method for clean and sanitary streets and make your town or city a better place in which to live.



Model FO2 Oil, Tar and Asphalt Distributor

We offer a complete line of Oil, Tar and Asphalt distributors. The MO models differ from the FO models in that the heat passes through the tank twice, whereas in the F models it passes three times.

Model FO2 with 2-speed transmission and oval tank. FO2C is the same as FO2 except that it is equipped with new type circulating spray bar.

Our Junior model FJ designed for light work and especially adaptable for mounting on small truck.

Models MO2 and MO2C correspond to models FO2 and FO2C, respectively, with the exception of heating system as mentioned above.

Write for full details.

FAIRBANKS, MORSE & CO.

CHICAGO, ILL.

Manufacturers of Power, Pumping and Weighing Equipment

Atlanta, Ga.	Chicago, Ill.	Denver, Colo.	Kansas City, Mo.	Milwaukee, Wis.	Philadelphia, Pa.	San Francisco, Calif.
Baltimore, Md.	Cincinnati, Ohio	Des Moines, Iowa	Los Angeles, Calif.	Minneapolis, Minn.	Pittsburgh, Pa.	Seattle, Wash.
Birmingham, Ala.	Cleveland, Ohio	Detroit, Mich.	Louisville, Ky.	New Orleans, La.	Portland, Ore.	St. Louis, Mo.
Boston, Mass.	Columbus, Ohio	Indianapolis, Ind.	Memphis, Tenn.	New York, N. Y.	Providence, R. I.	St. Paul, Minn.
Buffalo, N. Y.	Dallas, Texas	Jacksonville, Fla.		Omaha, Neb.	Salt Lake City, Utah	Syracuse, N. Y.

Fairbanks Contractor's Scales

By closely watching the needs of the industries it serves, Fairbanks, Morse & Co. has produced a number of scales which fit exactly the requirements of contractors.

For checking receipt and dispersal of aggregates —for weighing aggregates as a basis of payment for the job (a growing practice in many States)—Fairbanks has produced a self-contained motor truck scale which can quickly and easily be disassembled and transported from job to job. On a paving project, for example, this scale can be advanced along the job with the mixers or pavers.



A truck scale that you can move easily on the job—15-ton capacity, platform size 18'x9', code number 11997.

Weighing Aggregates Insures Strength

Special Fairbanks Scales have been developed to assist contractors in effecting all savings possible in materials and labor and to secure a uniformly high-grade of concrete. These scales provide an accurate, scientific control of the mixture of aggregates making a concrete batch by using weight measurements instead of volume. All weighing can be done on one scale, as the wheelbarrow scale is provided with a tare bar and two or three beams to be used for the sand, stone or other aggregates. They enable the contractor to meet rigid specifications on small jobs with a saving in material and labor cost. All of these scales in every way meet the specifications adopted by the American Road Builder's Association.



A single beam cement cart scale. The low platform is easy to approach and the light weight makes it easy to handle. Sturdy construction withstands hard usage.

Wheelbarrow Scales

Wheelbarrow scales are provided with three or four beams of non-corrosive metal. The upper beam is a blank tare bar to balance the empty wheelbarrows or cement carts. For weighing bulk shipments of cement in carts, a scale with only one beam is required. An over-and-under indicator to show exact balance is arranged so that it can be faced in any direction most suitable for easy view by the operator. This indicator is a simple device of the pendulum type, made without springs. When desired a bell-ringing attachment can be furnished to give an additional indication when the scale is in balance.

Code No.	Capacity	Platform	No. of Beams	Beam Graduations		
				Main 1	Fractional	Tare
11909	800 lbs.	42" x 30"	3	500 x 100 lbs.	100 x 2 lbs.	250 x 5 lbs.
11910	800 lbs.	42" x 42"	3 or 4	500 x 100 lbs.	100 x 2 lbs.	250 x 5 lbs.
11911	1200 lbs.	42" x 42"	1	700 x 100 lbs.	100 x 2 lbs.	400 x 5 lbs.

Fairbanks-Morse Products and Service

Fairbanks, Morse & Co. manufactures complete equipment for the economical generation of power, electric motors for driving various contractors' machines and pumps for practically all pumping requirements. A very important consideration in the selection of power equipment and motor-driven pumps for construction service is the manufacturer's ability to furnish complete equipment that has been designed as a unit—equipment that is backed by one responsibility and covered by a single guaranty.



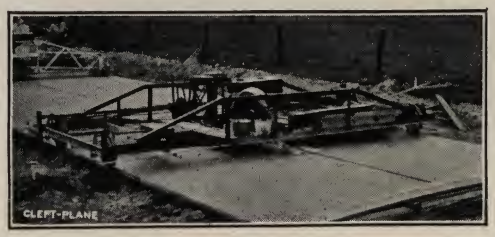
Typical Fairbanks Scales used in road paving, bridge building and culvert work.

FLEX-PLANE METHOD

of mechanically installing longitudinal and transverse joints



Flex-Plane No. 1—for screeding and installing any type of longitudinal or transverse contraction joint.



Flex-Plane No. 2—a lighter machine for installing any type of contraction joint.



Flex-Plane No. 3—our lightest installer operated with hand power, or can be trailed from finishing machine.

"A Contribution and Its Appreciation"

ONE of the great contributions to road building is the Flex-Plane Dummy Joint. Two thousand contractors have used it in building more than 15,000 miles of good concrete roads—enough to go half-way around the world. Engineers appreciate the Dummy Joint—and we appreciate this record. Prices are low and consistent and our service extraordinary. Ask any of the two thousand contractors what they think of Dummy Joints and our service.

Flex-Plane Installers leased at attractive prices.

The Flexible Road Joint Machine Company

Warren,
Ohio

CONSTRUCTION COST KEEPING and MANAGEMENT

by
H. P. GILLETTE
and
R. T. DANA



Successful engineers and contractors must be able to organize their records, plan their work, schedule their operations and standardize working conditions.

Construction Cost Keeping and Management co-ordinates and discusses the business principles underlying successful work in the construction field. This book fills a real need that will be more evident with the inevitable increase in construction work. The single purpose of this book is to increase by **greater efficiency** the margin of profit on every job.

Here in a single volume, fully illustrated, is a fund of practical experience which will serve as a guide to proper management. This book should be in every engineer's or contractor's library for constant use and reference.

TABLE OF CONTENTS

I.—Laws of Management. II.—Rules for Securing Minimum Costs. III.—Piece-Rate, Bonus and Other Systems of Payment. IV.—Measuring the Output of Workmen. V.—Cost Keeping. VI.—Cost Keeping as Applied to Highway Construction. VII.—Bookkeeping for Small Contractors. VIII.—Office Appliances and Methods. IX.—Miscellaneous Cost Report Blanks and Systems of Cost Keeping. X.—Systems of Cost Keeping.

Price $5.00

Ten Days' Free Examination

USE ORDER CARD NO. 1
on Page 137
when ordering your copy
of this book.

GILLETTE PUBLISHING CO.
400 W. Madison St. Chicago, Ill.

THE GALION IRON WORKS & MFG. CO.

Main Office and Works, Galion, Ohio

A SALES AND SERVICE ORGANIZATION COVERS THE ENTIRE UNITED STATES

Products: Straight and Leaning Wheel Graders, Motor Patrol Graders, Rollers, Maintainers, Spreaders, Drags, Scrapers, Snow Plows, Grading and Rooting Plows, Grader Blades, Culvert Pipe, Crushers, Portable Belt Conveyors, Bucket Elevators, Chains, etc.



Galion Rollers

The Galion line of Road Rollers includes: Little Master, International and the Galion Chief (shown at the left). The Chief, a 6-cylinder Motor Roller, is more massive, more powerful, with higher speed and finer performance, than any roller heretofore built.

The features of the Chief are: spring-mounted motor, Hydraulic steering, Hydraulic operated scarifier, electric starter, short wheel base, differential lock, and other important and improved features.

Write for Catalog No. 150, which gives complete details.

Galion Motor Patrol Graders

The Galion line of Motor Graders offers the most complete selection to meet any special requirement or condition. A Galion Motor Grader has never been known to fail in any task for which it was designed.

A Galion Motor Grader with Cletrac Tractor, solid tires in front and E-Z Lift Manual operation, is shown grading a road in the illustration at the right.

A choice of three leading power units; various types of wheel and crawler equipments; rear or center control; Hydraulic or E-Z Lift Manual operation. Write for complete information.



Galion Motor Patrol Grader equipped with Cletrac Tractor and E-Z Lift Manual operation



Galion Rear End Control Motor Grader with snow plow attachment

Galion Snow Plows

The Galion Motor Grader is a rapid remover for moderate depths. The new Galion snow plow or "breaker" increases the efficiency of the grader in clearing snow from the highways. This plow opens a six-foot path for the grader. The blade following widens the path and moves the snow to the outside of the road.

Attachment can also be used with Center Control Grader. Wheel equipment is optional.

Complete data on request.

Galion Motor Patrol Graders Equipped with Hydraulic Control

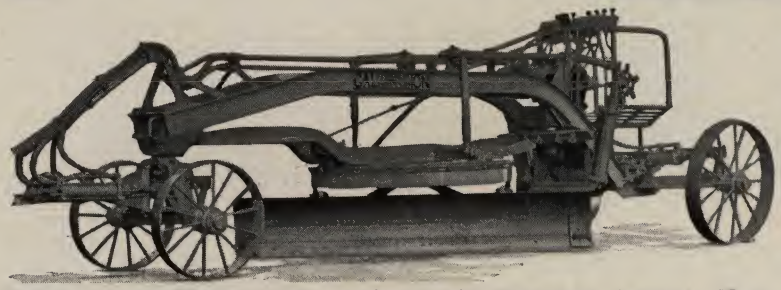
Hydraulic Control provides a new advantage in Motor Grader operation. There are no wheels to spin—no cranks to turn. All adjustments of the moldboard and scarifier are now controlled by three easy-moving levers, conveniently located, which reduce operation to a simple, effortless task.

A choice of three outstanding power units is available—McCormick-Deering, Cletrac or Case, providing a power to meet every requirement or condition.

Write for complete information.



Galion Motor Patrol Grader equipped with Hydraulic Power Control, Double Drive, McCormick-Deering Power, and zero-pressure tires



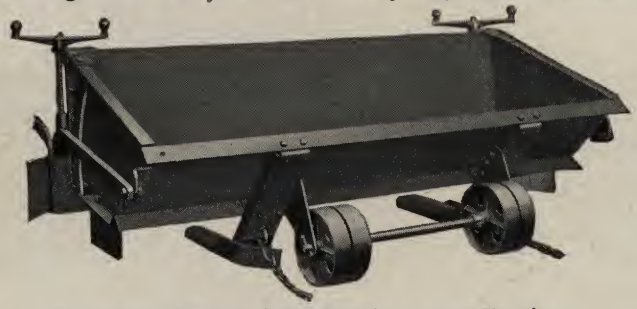
Galion Leaning Wheel Grader equipped with Hydraulic Control. Note the eight levers which make every adjustment necessary instantly

Galion Leaning Wheel Graders

Can now be equipped with Hydraulic Control—every adjustment can be made quickly and easily by touching one of the eight convenient levers. Also furnished with E-Z Lift Manual operation.

Galion Leaning Wheel Graders are furnished in a size and weight to meet every requirement you may have. Moldboards range in length from 7 to 14 feet.

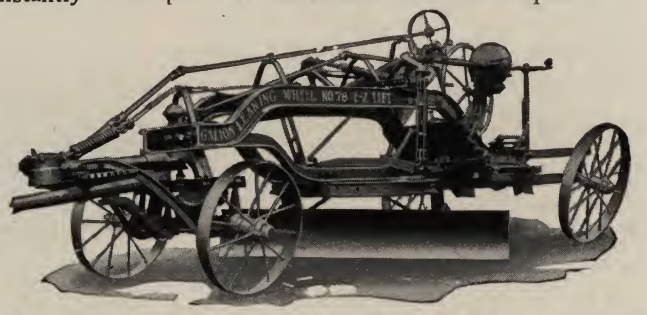
Complete information sent on request.



Stone and Asphalt Spreaders in 8 and 9 ft. sizes. Also Special Road Widening Types

Galion makes a Spreader for stone, mulch, slag, asphalt and concrete—also a Road-widening Spreader for spreading the above materials to the side of the old pavement without truck leaving the paved surface.

Galion also builds a Mixing and Leveling Drag for mixing and spreading mulch. Write for complete data.

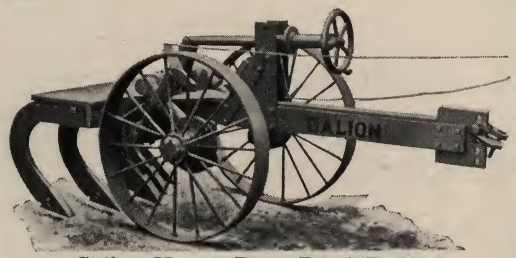


Galion No. 78 Leaning Wheel Grader for Moderate Service

There are 10 sizes of Leaning Wheel Graders to choose from. There are Galion Straight Wheel Graders in sizes with moldboards ranging from 6 feet 6 inches to 8 feet.

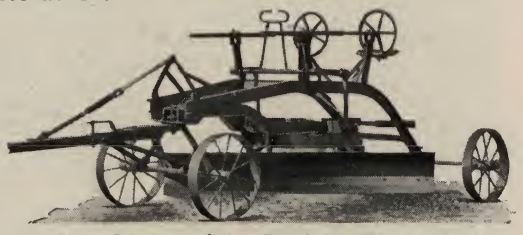
The lightweight "Pony" Grader (below) was designed for two-horse operation where light grading and general maintenance work is to be done.

Write for literature.



Galion Heavy Duty Road Rooter

The Heavy Duty Road Rooter is a recent development by Galion. It is a powerful rooter for breaking up old macadam, gravel, oiled roads and streets. Write for specifications. It is also used for loosening earth to be moved by graders or scrapers in the construction of fire breaks, reservoirs, dams, airports and railroads. Write for specifications.



Galion Light-weight Straight Wheel Pony Grader

Complete information will be sent on request

How to Bid and Make a Profit

ECONOMICS OF CONSTRUCTION MANAGEMENT

by

J. L. HARRISON

Engineer, Division of Management, U. S. Bureau Public Roads



This practical book is primarily concerned with the all-important question of bidding for a *Profit.*

The subject of Construction Management is treated by an author who has had practical contact with construction for 25 years. He has made a thorough study of administration and his present position on the staff of the Division of Management of the U. S. Bureau of Public Roads has allowed for close observation of construction problems.

The treatment outlines the fundamentals of economics in management in such a way as to give valuable information to the constructor *Who Must Bid to Make a Profit.*

TABLE OF CONTENTS

Read these chapter headings which tell the profit story from beginning to end:

The Origin of Profit—Financing Construction Work—Securing Business—Planning Operations—Purchasing the Materials Supply—Central Office Responsibility vs. Responsibility of the Job Management—Cost Accounts and Records—Production Cost and Expenses Other Than for Production—Expense Items Other Than for Production—The Control of Expense Other Than for Production—The Management of Production—Where the Plan of Operation May Fail—Units—Labor as a Factor in Cost—Materials — Operating Expenses — Depreciation — The Equipment Replacement Problem—Functional Adequacy and Dependability—The Value of Improvements in Equipment—Hauling—Financial Statements.

Size 5¾x8¼. Handsomely bound in blue cloth and gold. 330 pages.

Price $3.75

Ten Days' Free Examination

USE ORDER CARD NO. 5
on Page 137
when requesting your copy of this book.

GILLETTE PUBLISHING CO.
400 W. Madison St. Chicago, Ill.

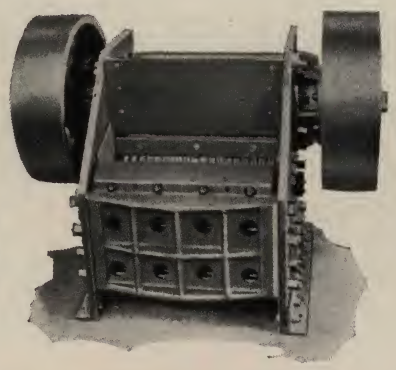
Good Roads Champion Quarry and Road Machinery

▼ ▼ ▼

A complete line of Crushed Stone and Sand and Gravel Machinery plus Expert Engineering Service:

ROCK CRUSHERS—Primary & Secondary
SCREENS—Vibrating & Revolving
ELEVATORS—Bucket, Chain or Belt
CONVEYORS—Belt
SCRUBBER SCREENS
SAND WASH BOXES
FEEDERS — GRIZZLIES
BIN GATES AND CHUTES

Built in Three Sizes
—
No. 1020
No. 1030
No. 1040

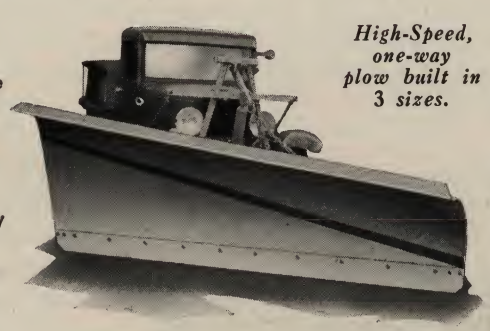


No. 1040 Roller-Bearing Fine Reduction Crusher

Road Building and Maintenance Machinery

GRADERS — DRAGS
ROAD OIL DISTRIBUTORS
SPREADERS—Chip, Sand or Cinders
SNOW PLOWS

A Complete Line of Reversible, One-Way and V-Type Plows



High-Speed, one-way plow built in 3 sizes.

For All Sizes of Trcuks

GOOD ROADS MACHINERY CORP.
22 Broad Street
KENNETT SQUARE, PENNA.

THE GRASSELLI CHEMICAL COMPANY

INCORPORATED CLEVELAND, OHIO FOUNDED 1839

New York and Export Office—350 Fifth Ave.

BRANCHES AND WAREHOUSES

Albany, Birmingham, Boston, Charlotte, Chicago, Cincinnati, Detroit, Milwaukee, New Haven, New Orleans, Philadelphia, Pittsburgh, St. Louis, St. Paul

Product: GRASSELLI "R-B" SILICATE OF SODA FOR CURING AND HARDENING CONCRETE PAVEMENTS.

Grasselli R-B Reg. U. S. Pat. Off. Silicate of Soda

Grasselli Silicate of Soda: "R-B" is a special grade of Silicate of Soda, which is recommended and used exclusively on concrete. This grade is a viscous liquid, weighs approximately 11¾ pounds per gallon, and is shipped in 50 gallon non-returnable steel drums.



Apply with spray on base work

Curing Concrete: Grasselli "R-B" Silicate of Soda has been used successfully as a curing agent throughout the United States and Canada and under all weather conditions. It has been thoroughly investigated by various Highway Laboratories and is now approved by the U. S. Bureau of Public Roads for use in Federal Aid Projects. Likewise, it is included in the specifications of States, Counties and Cities.

Applied to green concrete according to specifications, Grasselli "R-B" Silicate of Soda prevents the rapid evaporation of water by filling the pores and sealing the surface, thereby effecting thorough hydration of the cement with the mixing water and thus eliminating covering and sprinkling.

Grasselli "R-B" Silicate of Soda has no corrosive action on concrete. On the contrary, it improves the wearing qualities by filling the porous surface and producing a denser and likewise harder concrete. "R-B" is used exclusively as a surface application and not as an admixture.

Efficiency: Grasselli "R-B" Silicate of Soda curing is more easily controlled than the old methods of wet earth, straw or ponding and gives more uniform results than these methods, on the average job. Tests by the United States Bureau of Public Roads, Public Roads 9, 139 (1928); Georgia State Highway Department, Engineering News-Record 101, 170 (1928) and Professor A. N. Johnson, Roads and Streets 67, 175 (1927), as well as its successful use on concrete paving on state, county and city work, substantiate all claims for the efficiency of Grasselli "R-B." With this method the curing is never more than twenty-four hours behind the mixer and can be supervised at all times.



Apply with broom on slab work

The "R-B" method is very advantageous for city work as it eliminates the dirt and consequent dust incidental to the old methods of curing.

Simplicity: One application, either brushed or sprayed, completes the cure. No further attention is necessary. Sprinkling and covering are eliminated. Nothing to remove from the pavement when it is opened for traffic. The pavement is always visible for inspection. After "R-B" is applied, the curing takes care of itself.

Volume Change: The colorless properties of Sodium Silicate hold volume changes to a minimum. Checking or cracking from this source is virtually eliminated.

Economy: The cost of curing with Grasselli "R-B" Silicate of Soda is lowest because—

1—The cost of material is low

2—The cost of application is at a minimum

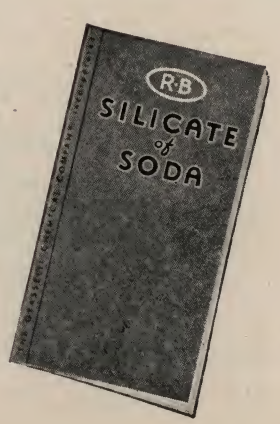
3—There is no storage required

4—No sprinkling or cleaning of the road

5—Permits maximum operation with water supply on hand

6—Cuts pumping cost in half

7—Pipeline can be removed when concrete is laid. Less pipe is required for the average job.



Booklet: Our booklet "Curing and Hardening Concrete Pavements with Grasselli 'R-B' Silicate of Soda" gives full description of this method, and will be mailed free upon request.

HARNISCHFEGER CORPORATION

ESTABLISHED IN 1884

4485 West National Ave., Milwaukee, Wis.

BRANCH OFFICES

Boston, Mass., 203 Chelsea St.
Chicago, Ill., 20 N. Wacker Drive
Cleveland, Ohio, 229 Rockefeller Bldg.
Dallas, Texas, 2223 Commerce St.
Detroit, Mich., 452 Book Bldg.
Hoboken, N. J., 1714 Willow Ave.
Indianaplis, Ind., 3043½ N. Pennsylvania Ave.
Jacksonville, Fla., 1052 East Bay St.
Kansas City, Mo., 1615 W. 51st St.
Los Angeles, Cal., 2025 Santa Fe Ave.
Memphis, Tenn., 307 S. Front St.
Minneapolis, Minn., 818 Lumber Exchange
New York, N. Y., Empire State Bldg.
Philadelphia, Pa., Broad Street Station Bldg.
Phoenix, Ariz., 132 N. 1st St.
Pittsburgh, Pa., Farmers Bank Bldg.
St. Louis, Mo., 7055 Dartmouth Ave.
San Francisco, Cal., 82 Beale St.
Seattle, Wash., 2911 First Ave. South
Washington, D. C., 7611 Georgia Ave.

P & H Products: GASOLINE, DIESEL, AND ELECTRIC SHOVELS, DRAGLINES, CLAMSHELLS, CRANES, SKIMMER-SCOOPS, TRENCH HOES, PILE DRIVERS, BACK-FILLERS, WHEEL OR LADDER-TYPE TRENCHERS, TAMPERS, TRUCK AND TRAILER CRANES. OVERHEAD ELECTRIC TRAVELING CRANES AND HOISTS. ELECTRIC MOTORS, GENERATORS AND LIGHTING PLANTS. ARC WELDERS, ARC TORCHES, WELDING FIXTURES.

P & H Excavators provide greatest yardage for lowest cost for highway contractors. Great power, fast crowd action, and synchronized speed mean more dirt moved per day. New type clutches and brakes absorb all shock and guard against breakage and high maintenance. Split Second Control assures faster and more accurate control . . . cuts down waste time . . . speeds up digging cycles.

INVESTIGATE THESE DISTINCTIVE FEATURES OF SPLIT SECOND CONTROL:

Sure-Feel Power Clutch
Full Vision Cab
Modernized Power Dipper Trip
High Production Main Clutches
Rapid Reversing Crowd Planetary
Super-Smooth Swing Clutch

AND IN ADDITION, NOTE THESE FEATURES OF THE P & H FULL REVOLVING LINE:

Fast, positive chain crowd
Unit cast steel construction
Heat treated and alloy steels on all important parts
Shafting of chrome-manganese steel
All shafts splined for extra strength
Centralized lubrication
All friction clutches of improved band type
Two speed tractions
Interchangeable shovel, dragline, crane, etc.
Traction gears fully enclosed in oil bath
Centralized full pressure lubrication
Fast, double safety boom hoist.
Steer entirely from cab
Leather upholstered operator's seat

Write for catalogs containing complete descriptions and specifications on the models in which you are interested. Road building contractors throughout the world invariably choose a P & H Shovel for efficient grading work.



You can spot the new P & H machines with the Split Second Control by the distinctive paint job. Durable Brewster Green on the lower and boom; aluminum on the cab. Good looking and practical, for it is easy to keep clean, cooler in summer and warmer in winter.

P & H-Hansen Electric Arc Welder

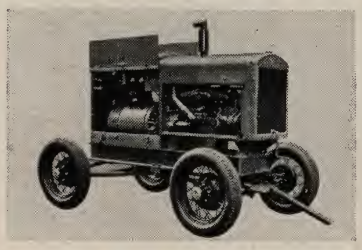
A portable, self-contained arc welding unit ideally adapted for all types of field service: machinery repairs, fabrication of structural steel, pipe welds and repairs, etc.

The P & H-Hansen Arc Welder is compact and remarkably simple to operate.

Simplified and patented construction details have made possible the elimination of many troublesome parts. Stabilization of the welding current is accomplished by a special method of winding—not with a heavy and cumbersome external stabilizer. An unusually wide current range is provided so that both light and heavy work can be handled on the same welder.

Available in the following capacities: 200, 300, 400, 600, and 800 Amps. Stationary, portable, and tractor mountings. Electric motor and gasoline engine drives.

Write for Bulletin containing complete information.



The P & H-Hansen Electric Arc Welder. Fast and simple to operate.

Working Specifications of P & H Shovels

	1400* WL	900A	800A	760	700B	650	600A	400	200A
DIPPER CAPACITY	4	3½	2½	2	1½	1¼	1	¾	⅜
LENGTH OF BOOM	34'0"	37'0"	34'0"	25'0"	25'0"	23'3"	23'3"	21'0"	17'0"
LENGTH OF DIPPER STICKS	22'6"	22'0"	20'0"	17'0"	17'0"	16'0"	16'0"	14'3"	12'0"
MAX. HEIGHT OF CUT	34'0"	36'0"	32'0"	32'6"	30'6"	30'3"	29'0"	25'0"	22'6"
MAX. DUMPING HEIGHT	22'6"	25'6"	22'0"	22'9"	21'9"	21'9"	21'6"	19'0"	17'0"
ROTATING SPEED	Complete Details	1.8 r.p.m.	3 r.p.m.	3 r.p.m.	3.5 r.p.m.	4 r.p.m.	4 r.p.m.	5 r.p.m.	5.5 r.p.m
HOIST SPEED	Upon Request	250 f.p.m.	215 f.p.m.	180 f.p.m.	155 f.p.m.	157 f.p.m.	152 f.p.m.	153 f.p.m.	161 f.p.m.
LENGTH DRAGLINE BOOM (STANDARD)		80'—110'	60'—80'	50'—80'	45'—70'	40'—60'	40'—60'	30'—50'	30'0"
SHIPPING WEIGHT —SHOVEL		315,000	215,000	131,000	105,000	88,300	81,000	56,500	29,500

*Ward Leonard models are also available in 2, 2½ and 3 yd. capacities

HAUCK MANUFACTURING COMPANY

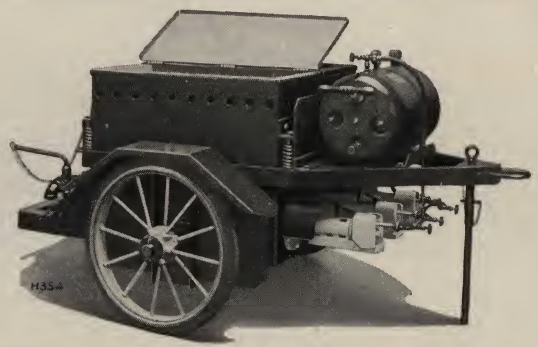
4657 West Harrison St., Chicago, Ill.

110-140 Tenth Street, Brooklyn, New York

296 Second St., San Francisco, Cal.

Oil Burning Highway Construction and Maintenance Equipment

Products: Asphalt Emulsion Sprayers, Asphalt Surface and Tool Heaters, Asphalt Kettles, Circular and Straight Flame Burners for Kettles; Heaters for Concrete Mixers; Thawers; Oil Burning Salamanders and Water Heaters; Kerosene Burners and Torches; Lead and Compound Melting Furnaces; Weed Burners; Burners for Oil, Tar and Asphalt Distributors; Burners for Asphalt Plants.



Combination Asphalt Tool and Cement Heater—see illustration—burns kerosene. Heats 16 or more tools in less than five minutes; heats asphalt cement ten minutes after starting. Asphalt melting kettle capacity 75 gals. Tool heating chamber 35″ wide, 12″ high and 55″ deep, and only 12″ above the ground. Three Burners—oil consumption one gallon per hour each. Fuel tank 20 gallons capacity. Made with steel or rubber tired wheels. Bulletin No. 751.



Asphalt, Tar and Pitch Kettles—Burn kerosene. Made in 50, 75, 100, 150, 200 and 300 gallon sizes—on legs and on steel, rubber and pneumatic tired wheels. Bulletin No. 652.

Hauck Patrol Kettle for heating asphalt pitch and tar for expansion joint filling and small patchwork; capacity 10 gallons. Ask for bulletin No. 104.

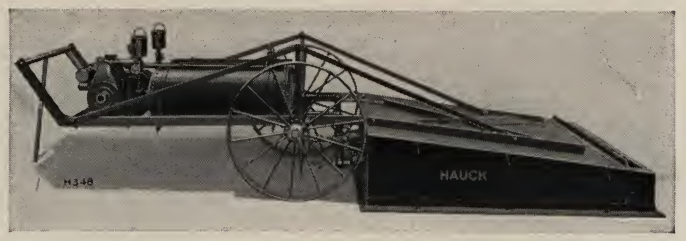
Heaters for Concrete Mixers, Thawers, Oil Burning Salamanders and Water Heaters—Concrete Heaters are approved by Highway Officials to heat the aggregates and water while mixing when the average temperature is below 40 deg. F. Temperature of the mix can be raised to 90 deg. F. or higher. Send for bulletin No. 2004.



Circular and Straight Flame Burners for heating asphalt, pitch and tar kettles; Torches for burning off high spots on asphalt pavements; drying brick pavements, etc., and general heating and repair work. Similar burners for oil, tar and asphalt distributors. Send for bulletins No. 201 and 551 on the various single and double burner equipments.

Weed Burners—burn kerosene—burn back the weeds the prescribed legal distance from the highway. Two to three burnings a year will control weeds—because it kills the seeds. Send for bulletin No. 602.

Asphalt Surface Heaters and Patchers—For heating and repairing bituminous pavements at less cost than cutting by the use of mattocks, etc. Two men with a double burner heater can do as much work as ten men by the old method. Made in two sizes, for kerosene—2 burner heater with hood 28″ x 48″; 3 burner heater with hood 48″ x 72″. The large size heater is also made for burning fuel oil, see illustration. Yardage per day with fuel oil heater—fair day 200, excellent day 500 square yards. Bulletin No. 752.



Lead Melting Furnaces are made in five sizes—portable and on wheels of 200, 450 and 850-lb. capacity. Melt 200 lb. of lead in ten minutes. Instant and positive heat control is obtained by the new "slide-rail" burner construction. Bulletin No. 101.



Hauck Compound Melting Furnaces for Hydro-Tite, Leadite, Mineral-Lead, G-K Sewer, Sewer Seal, and other Bituminous Compounds. Made in three sizes—8, 15 and 25-gallon capacities—on roller-bearing wheels. Ask for bulletin No. 103.



Power Cold Tar and Asphalt Emulsion Sprayers—Gear Pump Type for spraying curing emulsions and Pressure Type (no pump) for spraying penetration emulsions. Ask for bulletin No. 753.

Road Oil Distributor Burners—Give steady uninterrupted service for at least an entire season without any need for cleaning. The burner flame is of proper intensity, clean and without smoke. Made in 4 sizes. Bulletin No. 1020.



THE HELTZEL STEEL FORM AND IRON COMPANY

WARREN, OHIO

Representatives throughout the World—Export Department—Akron, Ohio

Presented here is the 1934 line of Improved Heltzel Products, designed to give all the features known to modern road building science. Outstanding as has been the recognition of Heltzel Leadership, these products, with their latest improvements, set still higher standards of efficiency. Heltzel has unsurpassed facilities for the manufacture of any of the products listed below. More than a quarter of a century of progress in the building of equipment, insures the highest standards of work, prompt service and a dollar's worth of value for each dollar invested in Heltzel Products.

Heltzel Steel Forms . . . for Concrete Construction . . . Road Forms, Curb, Combined Curb-and-Gutter, Integral Curb and Sidewalk Forms . . . Forms for Walls, Sewers, Subways, Tunnels, Bridges, Manholes, Concrete Pipe . . . Forms for Resurfacing with Macadam.



Heltzel Steel Road Forms

Heltzel Bridges . . . for constructing Roads . . . Adjustable Traveling Bridges, Longitudinal Float Bridges, Burlap Laying Bridges and One-Man Bridges.

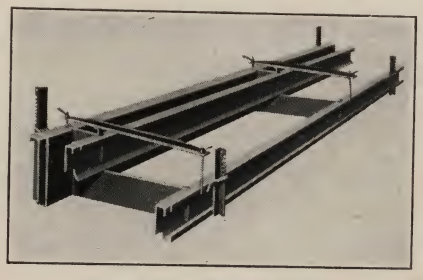
Heltzel Hand Finishing Tools . . . for finishing Concrete Streets or Roads . . . Straight Edges, Floats, Edging Tools and Lutes—all with long handles . . . Longitudinal Floats . . . Small Hand Tools of all description.

Heltzel Bituminous Handling Equipment . . . for Spreading and Mixing Bituminous Aggregate . . . Mechanical Spreader and Surfacer . . . Bituminous Coating Machines.



Heltzel Portable Aggregate Plant

Heltzel Steel Bins . . . for Storage, Handling and Batching Cement and Concrete Aggregates . . . Portable Batching Plants, Cement Bins, Central Mixing Plants, Rectangular, Square or Circular Bolted or Riveted Bins for bulk storage of granular materials.



Heltzel Steel Utility Forms

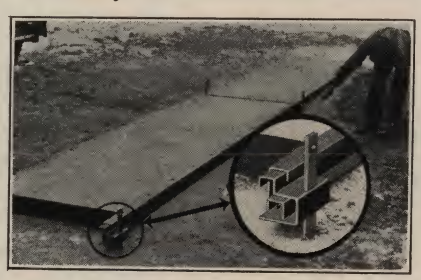
Heltzel Weighing Batchers and Scales . . . for measuring Cement and Concrete Aggregates accurately by weight . . . Batchers equipped with either Dial or Beam Scales—to meet any condition or specifications.

Heltzel Miscellaneous Road Equipment . . . for building Streets and Roads . . . Trail Graders, Subgrade Testers, Automatic Strike-Offs, Channel Strike-Offs, Road Division Plates and Bulkheads.

Heltzel Handling Equipment . . . for Contractors and Material Dealers . . . Coal Chutes, Bins, Car Unloaders, Mortar Mixing Boxes.

Heltzel Steel Plate Fabricating. . . . to customers' specifications . . . for Blast Furnace, Breweries, Chemical Plants, Cement Plants, Coal Dealers and Mining Companies, Engineering Companies, Factories, Foundries, Paint Works, Power Plants, Steel Industry, Wire Mills . . . Welded or Riveted Construction.

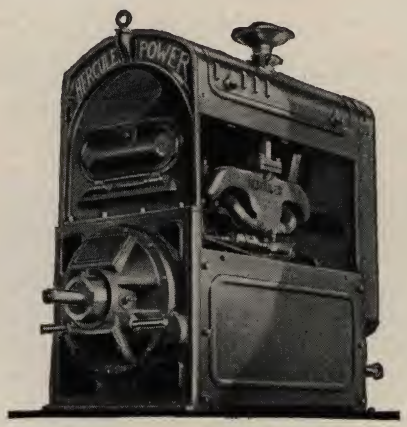
Flex-Plane Machines . . . for installing Longitudinal and Transverse Contraction Joints . . . Joint Machines for installing Ribbon, Poured or Premoulded Joints . . . can also be equipped with screed and curb building attachments . . . Leased by the Flexible Road Joint Machine Company, Warren, Ohio.

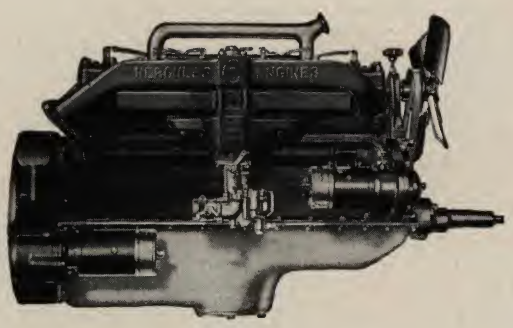


Heltzel Steel Sidewalk Forms

HERCULES MOTORS CORPORATION

CANTON, OHIO, U. S. A.





HERCULES HEAVY-DUTY ENGINES AND POWER UNITS

Hercules Power, ranging from 4 to 200 H. P., is obtainable as standard equipment on a large variety of applications including the following machines:

Air Compressors
Asphalt Plants

Backfillers
Blowers

Caisson Machines
Cane Mills
Centrifugal Pumps
Cobblestone Breakers
Combine Harvesters
Concrete Mixers
Conveyors
Cotton Gins
Cranes
Crawler Loaders

Dehydrators
Diggers
Ditchers
Drag Lines
Dredges
Drilling Machines (Standard & Rotary)
Dump Trucks

Electric Generators
Electric Light Plants
Electric Welders
Elevators
Excavators

Farm Tractors
Flour and Feed Mills

Gasoline Shovels
Graders
Gravel Plants
Grinders

Hammer Mills
Harvesters
High Pressure Pumps
Hoists
Hydraulic Machinery

Ice Saws
Industrial Tractors
Irrigation Pumps

Loaders
Locomotives
Logging Machinery

Marine Applications
Mining Machinery
Motor Coaches
Motor Trucks
Mowers

Oil Field Equipment

Pavers
Pile Drivers
Pipe Cleaning & Painting
Planters
Pulverizers
Pumps

Rail Cars
Refrigerating Machinery
Road Building Machinery
Road Maintenance Work
Road Rollers
Road Scarifiers
Road Scrapers

Sand Blasters
Sand Cutters
Saw Mills
Scows
Separators
Shredders
Shovels
Silo Fillers
Slush Pumps
Snow Loaders
Snow Plows
Speeders
Sprayers
Spudding Machines
Stand-by Equipment
Stone-Gravel Crushers
Street Sprinklers
Street Sweepers
Stump Eradicators

Taxicabs
Telephone Stations
Threshers
Track Layers
Track Shifters
Tractors
Trenchers
Turntables

Well Drillers (Oil-Water)
Winches
Wood Working Machinery

Yarders

SIZES OF HERCULES ENGINES AND POWER UNITS

4-Cylinder

Model	Bore and Stroke
ZXA	2½ x 3
ZXB	2⅝ x 3
IX	2½ x 4
IXA	3 x 4
IXB	3¼ x 4
OOA	3½ x 4½
OOB	3¾ x 4½
OOC	4 x 4½
OX	4 x 5
OXC	4¼ x 5
K	4¼ x 5¾
L	4½ x 5¾
G	4¾ x 5¾
E	5 x 5¾
TX	5½ x 7
TXA	6 x 7
TXO	6⅜ x 7

6-Cylinder

JXA	3⅜ x 4¼
JXB	3⅝ x 4¼
JXC	3¾ x 4¼
WXC	4 x 4½
WXC-2	4⅛ x 4½
WXC-3	4¼ x 4½
YXC	4⅜ x 4¾
YXC-2	4½ x 4¾
YXC-3	4⅝ x 4¾
RXB	4½ x 5¼
RXC	4⅝ x 5¼
HXA	4¾ x 6
HXB	5 x 6
HXC	5¼ x 6
HXD	5½ x 6
HXE	5¾ x 6

Hercules 6-Cylinder Diesel Engines

DRXB	4⅜ x 5¼
DHXB	5 x 6

HERCULES ENGINES

HERCULES POWDER COMPANY

INCORPORATED

WILMINGTON, DELAWARE

Manufacturer of Explosives and Blasting Supplies

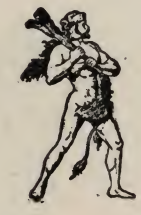
BRANCH OFFICES:

Allentown, Pa.	Denver, Colo.	Joplin, Mo.	Salt Lake City, Utah
Birmingham, Ala.	Duluth, Minn.	Los Angeles, Cal.	San Francisco, Cal.
Buffalo, N. Y.	Hazleton, Pa.	New York, N. Y.	St. Louis, Mo.
Chicago, Ill.	Huntington, W. Va.	Pittsburgh, Pa.	Wilkes-Barre, Pa.

PRODUCTS: Dynamite, Gelatins, Blasting Powder, Blasting Caps, Electric Blasting Caps, Waterproof Electric Blasting Caps, Delay Electric Blasting Caps, Electric Igniters, Electric Squibs, Safety Fuse, Cordeau, Leading Wire, Connecting Wire, Blasting Machines, Galvanometers, Rheostats, Cap Crimpers.

HERCULES DEVELOPMENTS FOR CONTRACTORS

Hercules has developed a complete line of explosives and blasting supplies to meet every blasting problem encountered by contractors. In addition, Hercules offers services and developments of unusual interest to contractors.



quarrying jobs. It is the only magazine devoted entirely to explosives and related subjects. The latest construction projects are covered completely from a blasting standpoint. Send for a free sample copy.

Accelerating Fill Settlement

The use of explosives to accelerate settlement of fill has revolutionized road construction methods over swamp areas. For those interested in applying this development, Hercules has prepared a comprehensive study of the most successful methods of accomplishing swamp fill settlement. This booklet, "Accelerating Swamp Fill Settlement with Explosives," will be sent on request to contractors or highway engineers interested in this work.

Hercules Contractor's Division

Our Contractor's Division makes a study of the requirements of contractors. In connection with our Service Division these specialists are prepared to assist contractors in the solution of explosives problems.

Hercules All-Metal Delay Electric Blasting Caps

For tunnel jobs the new Hercules All-Metal Delays are recommended because they speed production. These delays make use of a remarkable gasless fuse which requires no vent in the shell. Completely sealed, they are as waterproof as electric blasting caps, and can be imbedded in the primers without fear of causing burned holes. They cost no more than old-style vented delays.

The Explosives Engineer

Every month this magazine will bring you interesting articles covering important construction, mining, and

Hercules Gelamites

Hercules Gelamites are the outstanding explosives development of recent years. These explosives combine the desirable features of gelatins with the inherent economy of ammonia type explosives. They have saved money on many of the recent important tunnel and open-cut contracts.

Hercules Hercomites

Where these explosives can be used they will be found to be the most economical explosives for a large variety of work. Contractors everywhere have found that they will save money by replacing Extra L. F. Dynamite with Hercomite.

Other Hercules Explosives and Blasting Supplies

Hercules Extra L. F., Hercules Gelatin L. F., Hercules Gelatin Extra L. F., Hercules Blasting Gelatin and Torpedo Gelatin, Hercules Straight Nitroglycerin L. F., Hercules Permissible Explosives, Hercules Black Blasting Powders, Hercules Pellet Powder, Hercules Blasting Caps, Hercules Electric Blasting Caps, Hercules Delay Electric Igniters, Hercules Electric Squibs, Safety Fuse, Miners Squibs, Cordeau-Bickford, Leading and Connecting Wire, Hercules Blasting Machines, Galvanometers, Rheostats, Cap Crimpers, Portable Magazines, Augers, Tamping Bags.

HIGHWAY STEEL PRODUCTS COMPANY

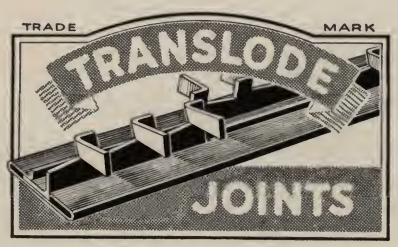
MANUFACTURERS

Steel Products for Concrete Road Construction

CHICAGO HEIGHTS, ILLINOIS

BIRMINGHAM, ALABAMA — ST. LOUIS, MISSOURI

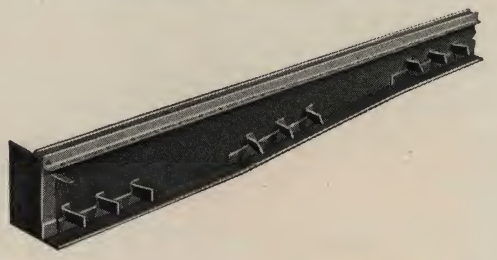
PRODUCTS: Translode Expansion and Contraction Joints, Marker-Seal, Center Strip, Stakes, Bar Supports, Dowel Sockets, Metal Ditch Checks, Recess Forms and other metal road materials.



HIGHWAY STEEL PRODUCTS COMPANY manufactures a complete line of metal products for use in concrete road construction.

Quotations for special metal products for concrete roads quickly furnished on request.

Translode Expansion Joints



Translode Joints are designed to transmit load across the joints without the use of dowel bars. The Translode base may be used with any type of filler or with a metal air joint as shown. Its use will keep the adjacent slabs permanently aligned in the same plane under any traffic or subgrade condition. The Translode air joint is sealed at the top, bottom and sides and will maintain a uniform expansion interval for the life of the pavement without maintenance expense.

Translode joints are now specified for general use by some States.

Metal Center Strip



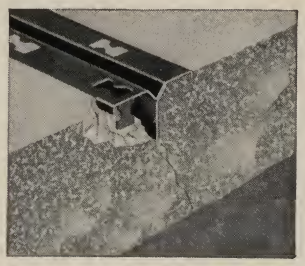
This type of metal center strip provides a tongue and groove contraction joint down the center of the road, to hold the two slab sections in alignment in the same plane. The tongue and groove center joint has long been recognized as the most efficient type of longitudinal joint.

Central Strip Accessories



Highway dowel and marginal chairs and channel type center strip stakes have been in general use over the United States for many years. **All types of chairs and stakes are manufactured to meet the specifications of any State.**

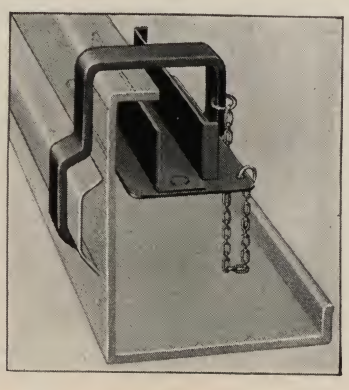
Highway Marker-Seal



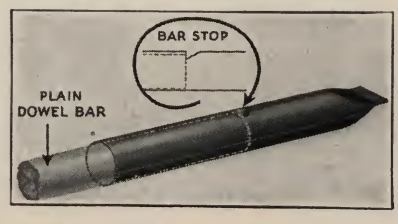
Highway Marker-Seal is a combination weakened plane longitudinal joint former and permanent traffic line marker. It is designed with lugs punched down from the horizontal flanges to tie the adjacent slabs together at the joint. **The use of tie bars is eliminated as the Marker-Seal itself has a much greater tying efficiency than ½-in. tie bars on 5-ft. centers.** Marker-Seal requires no painting and provides a clearly visible traffic line in day or night. The saving in this maintenance makes Marker-Seal the most economical type of center joint.

Recess Forms

Recess Forms are used where one section of slab is laid before another to provide a groove in which tie bars are held until the second slab is poured. The tongue and groove joint so formed holds the two slabs in perfect alignment. Clamps are removed after the concrete is poured and the pressure of the concrete holds the recess form tightly against the side form.



Dowel Bar Sockets



Dowel sockets for use over one end of dowel bars can be furnished in any length or size to meet State requirements. The louvre bar stop prevents the bar from being inserted more than the required length during construction.

THE JOS. HONHORST CO.

1016-18-20 West Sixth Street,
CINCINNATI, OHIO

PRODUCTS MANUFACTURED—
Oil, Tar, and Asphalt Distributors.

Tanks—Welded and Riveted
Smoke Stacks—Salamanders—
Pouring Pots—Sand Dryers—Tool Boxes—Tool Heaters

Asphalt and Tar Heating Equipment for Street, Road, Pipe Line and Highway Work

We present here the improved 1931 line of HONHORST HEATERS, all designed to give a dollar's worth of value for each dollar you invest in our equipment. Outstanding as has been the recognition of Honhorst Leadership, these Heaters, with their new improvements set still higher standards of efficiency.



This is our Oil Burning Heater—for heating Asphalt, Tar and Pitch. Used by road contractors and Highway Departments. It is ideal for the heating of dope by Pipe Line layers. Made in 65 to 200 gallon capacity. Write for our Pamphlet No. 15.



Our Style E Heater is designed for using wood, coal or coke for fuel, and is a quick heating, efficient addition to the equipment of any contractor or Highway Department. Sizes 65-110-165 and 200 gallon capacity. Send for Pamphlet No. 13.



A Heavy Duty Heater, admirably suited for large contracts on highway work, or any place where tar or compounds are used in large quantities. Sizes 250-350-500-700 and 900 gallon capacity. Rubber tires and heat guards optional.



This Patrol Heater is especially designed for small repair jobs and patch work. The Kettle is welded leakproof. Weight 190 lbs. Capacity 25 gallons.

All Types and Sizes of Heaters in Stock—Write for Catalogue and Prices.

INDUSTRIAL BROWNHOIST CORP.

GENERAL OFFICES: BAY CITY, MICHIGAN

DISTRICT OFFICES ..

NEW YORK, 50 Church Street — CHICAGO, 208 So. La Salle St. Bldg.

PHILADELPHIA, Broad St. Station Bldg. — CLEVELAND, 4403 St. Clair Ave.

PRODUCTS: Locomotive Cranes, Erection Cranes, Crawler Cranes and Shovels, Pile Drivers, Clamshell Buckets, Bins, Conveyors.

LOCOMOTIVE CRANES

7½ to 200 Tons Capacity

Industrial Brownhoist builds the world's largest and most complete line of locomotive cranes—a type and size to meet any demand. Each is a leader in its capacity class and will effect great savings on every job. Gasoline or Diesel power drive can be furnished on sizes up to 40 tons and steam operation on cranes of ten tons capacity or over.

TYPE BC SHOVEL CRANE

¾ Yd.-1⅛ Yd. Shovel—22½-25 Ton Crane

The Type BC crawler is a heavy-duty shovel-crane-dragline, powered by gas, Diesel, steam or electric drive. It is unusually fast and easy operating and is one of the outstanding machines on the market because it embodies many features found on probably no other machine of its type. Among these are two speed hoist; two speed travel; a steering controlled entirely independent of all other motions; power operated clutches; quick convertibility.



Type BC shovel on excavation work.

TYPE BH SHOVEL CRANE

¾ Yd. Shovel—7½ Ton Crane

Part for part no simpler nor more rugged machine has been built than the Type BH. It has proved its reliability in practically every industry and will turn out a big day's work at very low cost.

TYPE IW SHOVEL CRANE

½ Yd. Shovel—6 Ton Crane

The Type IW is a sturdily built, gasoline operated machine, readily convertible to shovel, crane or dragline. It has the simplest design in its capacity class and possesses all the advantages you should demand in a shovel or crane of its type.

BUCKETS

Industrial Brownhoist buckets are built in a complete range of types and sizes; Utility Clamshells for rehandling work, ½ to 2 yards capacity; Heavy-Duty Clamshells for excavating service, ½ to 1½ yards capacity; Link-type buckets for coal and ore handling.

—a reference book for Engineers, Architects, Contractors and Builders—

LABOR COSTS of CONSTRUCTION

by

FRANK L. CONNOR



The purpose of this book is to prepare those who will want to capitalize on the increase in construction jobs to go after real profits on a *sound basis.*

This material all drawn from years of practical experience on hundreds of jobs will provide you *facts* with which you can intelligently figure your estimates. Labor Costs of Construction gives a simple yet effective method of checking labor costs under any local rate. Here are numerous tables and data that will enable you to *test your estimates* and cost figures so you can make a profit.

Are you going back into the battle with the same equipment, knowledge and methods? Or are you going to prepare by using Labor Costs of Construction as a guide?

TABLE OF CONTENTS

Contents. I.—Earth Excavation and Transportation. II.—Rock Excavation. III.—Sheet Piling and Cofferdams. IV.—Wood and Concrete Piles. V.—Concrete Costs. VI.—Concrete Form Costs. VII.—Steel Reinforcing. VIII.—Structural Steel. IX.—Timber Work. X.—Rough and Finish Carpenter Work. XI.—Brick and Tile. XII.—Masonry. XIII.—Plastering and Plumbing. XIV.—Painting. XV.—Sewers. XVI.—Water Works. XVII.—Concrete and Other Paving Costs. XVIII.—Equipment and General Labor Expense.

Price $3.00

Ten Days' Free Examination

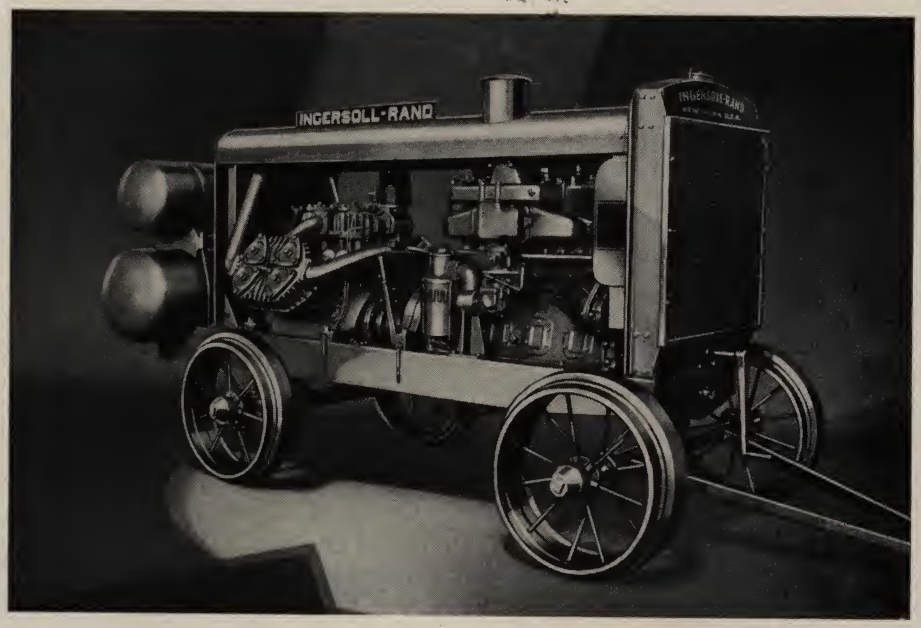
USE ORDER CARD NO. 4
on Page 137
when requesting your copy of this book.

GILLETTE PUBLISHING CO.
400 W. Madison St. — Chicago, Ill.

A new deal in Portable Air Compressors

23% more air

25% less fuel per foot of air delivered



Two-Stage Air-Cooled Oil-Engine or Gasoline-Engine Driven Portable Air Compressors

Gasoline Engine Units

Size of Compressor	Actual Delivery Cu. Ft. /Min.	No. of Air Cylinders	No. of Engine Cylinders	RPM	Weight Complete on Steel Wheels
75	57.5	2L.P.-1H.P.	4	830	2,275
125	102	2L.P.-1H.P.	4	830	3,485
185	152	2L.P.-1H.P.	4	830	5,475
250	204	4L.P.-2H.P.	4	830	5,960
370	304	4L.P.-2H.P.	4	830	7,310
XL	413	1L.P.-1H.P.	4	830	16,000

Oil Engine Units

Size of Compressor	Actual Delivery Cu. Ft. /Min.	No. of Air Cylinders	No. of Engine Cylinders	RPM	Weight Complete on Steel Wheels
75	57.5	2L.P.-1H.P.	4	830	2,510
125	125	2L.P.-1H.P.	4	830	3,950
185	152	2L.P.-1H.P.	4	830	5,700
250	204	4L.P.-2H.P.	4	830	6,050
370	304	4L.P.-2H.P.	4	830	8,600
XL	413	1L.P.-1H.P.	4	300	16,000

Ingersoll-Rand has developed a complete line of air tools for use with portable compressors

Birmingham
Boston
Buffalo
Butte
Chicago
Cleveland
Dallas
Detroit
Denver
Duluth
El Paso
Knoxville
Los Angeles
Newark
New Orleans
Philadelphia
Pittsburgh
San Francisco
Salt Lake City
Scranton
Seattle
St. Louis
St. Paul
Tulsa
Washington

Ingersoll-Rand

11 BROADWAY
NEW YORK, N. Y.

INTERNATIONAL HARVESTER COMPANY

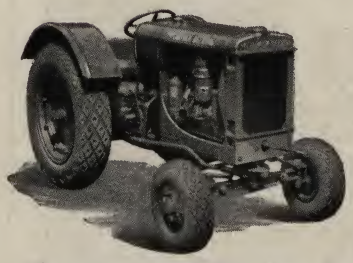
OF AMERICA

(INCORPORATED)

Industrial Tractors Power Units Motor Trucks

606 South Michigan Ave.

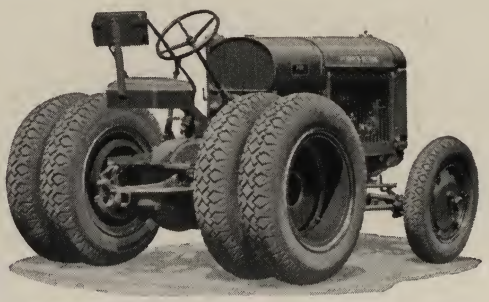
CHICAGO, ILL.



The new McCormick-Deering I-12 Industrial, a nimble tractor, handy and economical on any job.

The International Harvester line of industrial power equipment includes crawler and wheel-type tractors in a variety of sizes, stationary power units in gasoline and Diesel types, and International trucks ranging in sizes from ½ to 7½-ton capacities.

McCormick-Deering wheel-type industrial tractors include four models, the I-12, the I-30, and Models 20 and 30. They supply power through drawbar, belt pulley, and power take-off. The I-12, the latest addition to the line, is an ideal unit for shop and factory hauling, dock and warehouse use, for many municipal and public utility applications, for parks and airports, and also a mighty handy utility unit for contractors. It has a speed range of 2¼ to 10⅜ miles per hour and has unusual pulling capacity for a tractor of its size.



McCormick-Deering industrial tractors are equipped with the spring-cushioned pintle-hook drawbar.

McCormick-Deering Power

The McCormick-Deering industrial tractors are on the roads of every state, building and maintaining highways the year around. They operate as individual units, powering a long list of construction and maintenance equipment. More than one hundred manufacturers are building equipment for the application of McCormick-Deering power. This includes shovels, clam shells, bulldozers, trail builders, excavators, ditchers, scrapers, road rollers, scarifiers, sweepers, snow plows, logging equipment, cranes, locomotives, and all forms of equipment operating from the drawbar.

The various units of the tractors, such as the engine, clutch, transmission, etc., can be removed separately without disturbing adjacent parts. All working parts are thoroughly protected from dust and dirt.

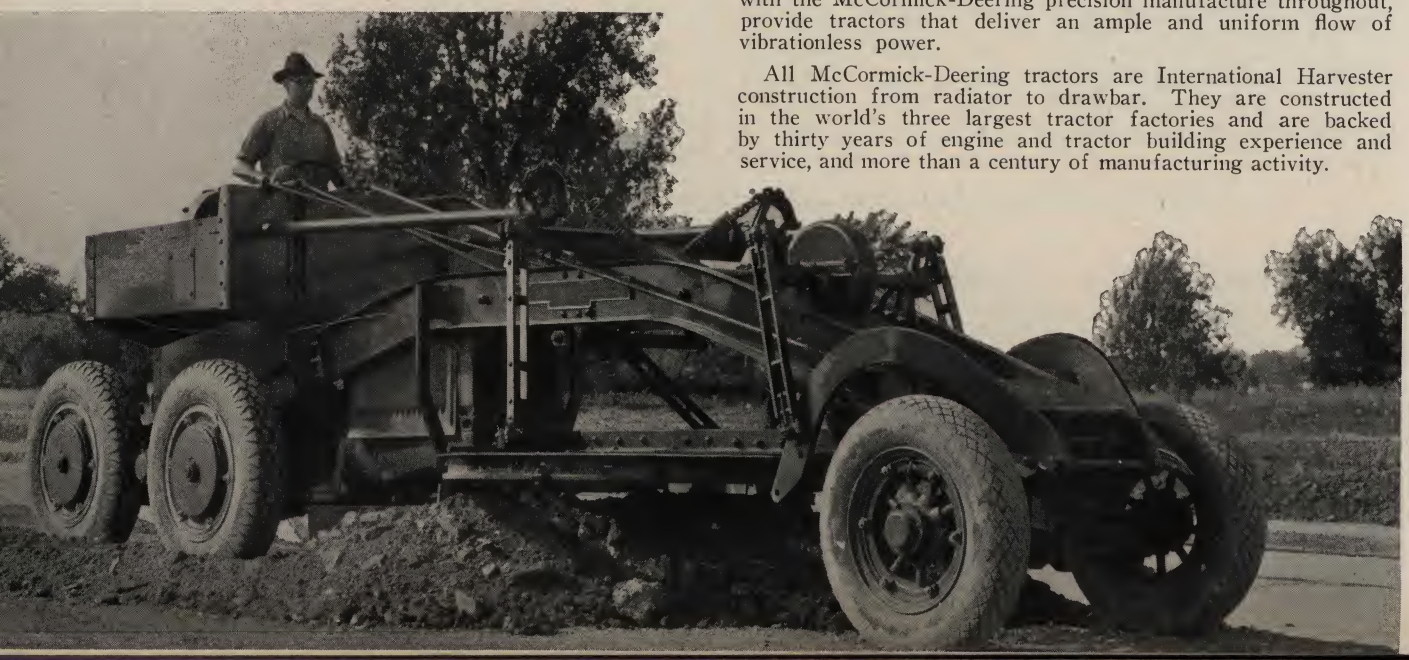


The McCormick-Deering industrial tractors are similar in design and construction. The Models I-30, 20 and 30 can be obtained with a variety of wheel and tire equipment.

Heavy Duty Engines

The heavy-duty four-cylinder tractor engines have the famous McCormick-Deering replaceable cylinders, are equipped with high-tension magneto, with automatic impulse starter, fuel strainer, air cleaner, and oil filter. These features, combined with the McCormick-Deering precision manufacture throughout, provide tractors that deliver an ample and uniform flow of vibrationless power.

All McCormick-Deering tractors are International Harvester construction from radiator to drawbar. They are constructed in the world's three largest tractor factories and are backed by thirty years of engine and tractor building experience and service, and more than a century of manufacturing activity.



INTERNATIONAL HARVESTER COMPANY

OF AMERICA

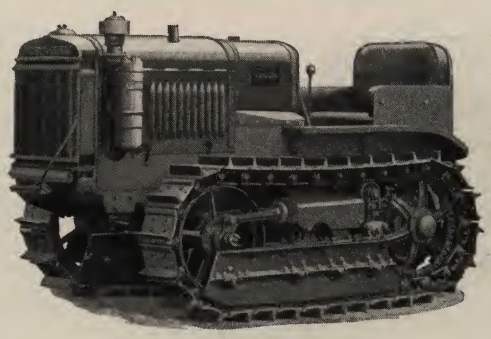
(INCORPORATED)

Industrial Tractors Power Units Motor Trucks

McCormick-Deering TracTracTors

McCormick-Deering TracTracTors are the only crawler tractors on the market with steering clutches and steering brakes fully accessible; with removable cylinders, and with ball bearings throughout that require no adjustments.

The TracTracTors with positive-grip tracks provide low cost power for a variety of industrial, commercial, and construction applications. Like the industrial tractors and power units, they are McCormick-Deering construction throughout. They are the most accessible crawler tractors built—the steering clutches and steering brakes can be inspected, adjusted, and replaced without disturbing the tracks, track frames, or driving sprockets. The value of this feature is readily appreciated by every crawler tractor owner and operator.



THE T-20 TRACTRACTOR

A readily maneuvered crawler tractor for road construction and maintenance work.



The Diesel 40 TracTracTor operates on small quantities of low-grade fuels. This tractor can also be obtained with a six-cylinder gasoline engine if preferred.

Flexible Crawler Tractors

The McCormick-Deering TracTracTors provide versatile, yet heavy-duty, power on a long list of highway work. The T-20, delivering a maximum of 25 drawbar horsepower, has three traveling speeds of 1¾, 2¾, and 3¾ miles per hour. The T-40 TracTracTors, whether powered with the six-cylinder gasoline engine or the 4-cylinder Diesel, deliver a maximum of 44 drawbar horsepower. The engines have 4 governed speeds and the transmission provides five forward speeds. This flexibility gives twenty traveling speeds—a variety never before offered.

High-Grade Construction

McCormick-Deering TracTracTors are constructed with ball-bearings throughout—there being 44 in the T-40. The transmission, final drive, and driving sprockets are mounted in ball bearings. Ball bearings are self-aligning, a feature greatly appreciated when service is required.

The tractor frame, the driving sprockets, bearings, front idlers, and upper and lower track rollers are protected with triple dust seals. The idlers and track rollers run in oil, a feature that reduces friction to a minimum.



INTERNATIONAL HARVESTER COMPANY

OF AMERICA

(INCORPORATED)

Industrial Tractors Power Units Motor Trucks

McCormick-Deering Power Units



McCormick-Deering Model P-30 Power Unit, developing 35 horsepower. The engine has a ball-bearing crankshaft, impeller pump for cooling, oil filter, enclosed bell housing, and many other features.

Power Units

McCormick-Deering power units are supplied in four sizes, Models 200, 300, P-30, and PD-40. They range in capacity from 30 to 52 horsepower. The PD-40 is Diesel type and has the outstanding advantage that it can be started by cranking as readily as a gasoline engine of corresponding size. This is accomplished by a unique device—exclusively McCormick-Deering—which converts the engine into a conventional gasoline engine for starting. This starting arrangement eliminates the costly and less reliable devices such as auxiliary engines or electric starters with heavy-duty batteries. As soon as the engine has attained proper speed, it shifts automatically to Diesel operation.



The McCormick-Deering 300 power unit delivers 45 belt horsepower. The Model 200, similar in construction, delivers 30 horsepower.

The engines in the McCormick-Deering power units are of the same type and construction as the engines in the industrial tractors of corresponding sizes. They have the time and money-saving replaceable cylinders. high-tension magneto with automatic impulse starter, and other features that have gained the approval of users of McCormick-Deering power.

These units are complete with a base mounting, control panel, clutch, and belt pulley. All can be equipped to deliver power through belt, gear, chain drive, or direct connection.

McCormick-Deering power units are in every-day use driving crushers, gravel conveyors, and pumps, operating elevating graders and shovels, excavators and mixers, locomotives, dredges, and similar equipment.



The McCormick-Deering Diesel Power Unit, PD-40, a heavy-duty Diesel that can be started on gasoline and automatically shifted to Diesel operation. This is the same engine that powers the McCormick-Deering Diesel 40 TracTracTor.

McCormick-Deering Service

This service is available through more than 100 Company-owned branches throughout the United States and Canada, scores of distributors, and thousands of dealers, where parts and service are immediately available. Catalogue and complete information will be supplied upon request.



INTERNATIONAL HARVESTER COMPANY

OF AMERICA

(INCORPORATED)

Motor Trucks, 1/2 to 7 1/2 Tons Rated Capacity, Industrial Tractors, Power Units

606 South Michigan Avenue
CHICAGO, ILL.

Where the going is tough and loads are heavy, that is where rugged International speed and heavy-duty trucks show their mettle. Excavation contractors and road builders know their Internationals, and the steady growth of large International fleets in the past few years is conclusive evidence that these rugged trucks are satisfactory in every way—they are great trucks for work.

To appreciate fully the performance and sturdy construction of International trucks, it is necessary to inspect and drive them. Power, speed, economy, ease of handling and stopping ability—the advantages needed in present-day truck operation—are all there in good measure.



An International heavy-duty truck with concrete mixer.

There is an International Harvester truck in a size and type to meet every hauling requirement. These units range from the Model C-1, a ½-ton unit with all-steel pick-up body, to the massive 7½-ton Model A-8.

International Service

International Harvester considers the permanence of its service network a factor of inestimable importance. International Truck owners today contact factory service methods and standards at 181 Company-owned branches and service stations, supplemented by many hundreds of International Truck dealers whose service facilities are fully approved by the Company.

This extensive service organization is as securely grounded as the plants that build the trucks. The substantial character of our branch houses throughout America in itself gives proof of permanence—and this visual evidence is backed by the history and conservative reputation of the Company.

Thousands of truck users have standardized on International Trucks because of the thoroughness of International service and assurance of its permanence. Hundreds of fleet owners have



International trucks point the way to increased profits through dependability and operating economy.

absolved themselves of all service responsibility, putting their trust entirely in the International facilities. International Harvester values this intimate association with International Truck ownership far too highly to alter it except to effect improvement in the service wherever possible.

A post card or telephone call to the nearest branch or dealer will bring complete information on any International model.



International trucks meet the rigid requirements of city, county and state highway departments.

C. R. JAHN COMPANY

BUILDERS BUILDING — EXCLUSIVE DISTRIBUTORS FOR — CHICAGO, ILLINOIS

AUTOMOTIVE PRODUCTS DIVISION
LA CROSSE BOILER COMPANY
La Crosse, Wisconsin

Manufacturers of La Crosse Tu-Way Trailers (Patents Pending)

Dealers in All Principal Cities

LA CROSSE HEAVY DUTY MACHINERY TRAILERS are scientifically designed to transport SHOVELS—TRACTORS and other heavy construction materials. THE FULLY REVERSIBLE FEATURES that mean so much in tight places are found only in LA CROSSE TU-WAY TRAILERS—PULL FROM EITHER END—LOAD FROM EITHER END OR SIDE—EIGHT WHEEL STEER—EIGHT WHEEL BRAKES—FULLY REVERSIBLE. STANDARD MODELS UP TO 33 TON FURNISHED IN EIGHT-FOOT WIDTHS—SOLID OR PNEUMATIC TIRES—4 - 6 - 8 - 12 and 16 WHEELS.

FLAT PLATFORM permits loading from either end or sides. Provides for shortest possible wheel base and over-all length without sacrificing loading space. The new La Crosse Tu-Way with its flat platform eliminates the necessity of high front deck, thereby reducing loading height and weight of the trailer.



Model LC—8 Wheels Capacities to 50 Tons

Below: **The illustration shows the successful test, by government and Six Companies, Inc., engineers, of the largest trailer ever built. This trailer will handle the mammoth pen-stock pipes for Boulder Dam (the largest pipes in the world), transporting them from the fabricating plant to the government Cable-Way above the canyon.**

Trailers of Every Description Designed and Built for all Special Purposes



Special 16-Wheel Trailer; Test Load 235 Tons—Gross

LA CROSSE TU-WAY TRAILERS

JOHNS-MANVILLE

Executive Offices: 22 E. 40th St., New York

OFFICES IN ALL LARGE CITIES

Asphalt Plank, Expansion Joints, Culvert Pipe

J-M Asphalt Bridge Plank

J-M Asphalt Bridge Plank, a mixture of asphalt, fibre and finely divided mineral filler, is the outstanding bridge surfacing on the market today. It will not warp, crack, splinter or decay. It is strong, durable, resilient and practically wear-proof. It can be applied quickly and easily and is ready for traffic as soon as it is laid.

The light weight of J-M Asphalt Bridge Plank is of particular advantage in the many instances where minimizing the dead load is an important consideration. It is reasonable in first cost and, on the many bridges where it has been used, the usual costly item of maintenance has been almost entirely eliminated.

J-M Mineral-Surfaced Asphalt Bridge Plank—In addition to the conventional smooth-surfaced plank, Johns-Manville has recently developed a new and improved material with a mineral surface which provides traction, when wet, fully as good as that of concrete. By a special manufacturing process, coarse trap rock is embedded in the surface under hydraulic pressure, permanently interlocking the stone with the asphaltic body of the plank. The pressure under which the material is formed also increases its density and toughness.

Sizes and Thicknesses Furnished—Mineral-Surfaced Plank is furnished 12″ x 24″ in 1″, 1¼″ and 1½″ thicknesses. Standard Smooth-Surfaced Plank is available in thicknesses from ½″ to 2″, widths of 8″ to 12″, and in lengths from 48″ to 72″.



Close-up of a bridge surfaced with J-M Mineral-Surfaced Plank. Light weight, easy application and excellent traction are among its outstanding characteristics

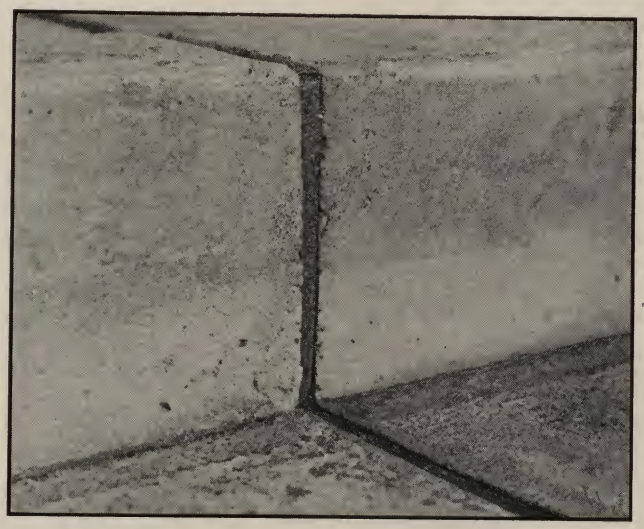
Recommendations—Over smooth, solid sub-floors such as steel, concrete or matched, surfaced timber, the 1″ thick plank is recommended. Sub-floors which are not smooth or which deflect appreciably under normal loads require the 1¼″ or 1½″ thickness.

Detailed information, including specifications for application over various types of decks, may be had on request.

J-M Cork Expansion Joint

Because of its enduring resiliency and its remarkable ability to recover after long periods of compression, J-M Cork Expansion Joint cannot be displaced from the joint space. Summer or winter, year in and year out, it fills the joint completely at all times, providing constant effectiveness without maintenance.

Made of carefully selected cork particles bound together with a phenol formaldehyde type resin, J-M Cork Expansion Joint has all the lasting resiliency of cork wood and, in addition, the chemical permanence of a synthetic resin.



J-M Cork Expansion Joint cannot be displaced under the pressure of expansion, and recovers thickness as the pavement contracts

Other Advantages—J-M Cork Expansion Joint is not ruptured by heavy loads; is impervious to air and water; is unaffected by freezing and thawing; is not softened by high temperatures; and is easy to handle and install.

Sizes Furnished—J-M Cork Expansion Joint is available in any length up to 20 feet, in standard widths up to 36″ and in standard thicknesses from ⅛″ to 1″.

Specifications—Specifications and detailed information will be gladly furnished on request.

Transite Pipe for Culverts

While Transite Pipe was originally designed as pressure pipe for water transportation, highway engineers throughout the country have been quick to recognize its obvious advantages for culverts.

Composed of asbestos fibre and portland cement, combined under tremendous pressure, it will not rust or deteriorate and never requires surface treatment, inside or out. Its immunity to soil corrosion and other destructive agencies assures permanence without maintenance. In strength, it more than meets State and Federal specifications. And, because of its light weight and the long lengths in which it is furnished, it can be laid easily and quickly.

Complete information will be furnished by any Johns-Manville office.

KALMAN STEEL CORPORATION

Subsidiary of: BETHLEHEM STEEL CORPORATION

Manufacturers of Steel for Concrete Highways

General Offices:
BETHLEHEM, PA.

Albany, N. Y.	Buffalo, N. Y.	Detroit, Mich.	Minneapolis, Minn.	St. Louis, Mo.
Atlanta, Ga.	Chicago, Ill.	Houston, Tex.	New York, N. Y.	St. Paul, Minn.
Baltimore, Md.	Cincinnati, O.	Milwaukee, Wis.	Philadelphia, Pa.	Syracuse, N. Y.
Boston, Mass.	Cleveland, O.		Pittsburgh, Pa.	Washington, D. C.

Export Distributor: BETHLEHEM STEEL EXPORT CORPORATION, New York, N. Y.

If it's STEEL for Highway Construction— We Have it . . . ANYWHERE at ANYTIME

19 Kalman sales offices, warehouses and agencies are located in strategic centers of road-building activity. That means your order for any sort of steel for concrete-road building will arrive where you want it when you want it. That means an end to the worry and expense of delayed shipments. Ask us to send you more details of this complete service.

Bar Mats



Kalman Bar Mats consist of Bethlehem Deformed Bars, spaced as required, and securely fastened by Kalman Bar Clips. This device gives all needed rigidity to the mat, and preserves bar spacing and alignment with just enough flexibility to allow the mat to lie flat. Mats fabricated by this method facilitate handling, thus speeding the work.

Contraction Joint (Road Strip)

The Kalman Road Strip or Center Strip is a so-called V-type contraction joint. It is approved wherever this kind of longitudinal joint is used. It is made to specifications as to gauge, length, width, depth of "V" and punching for dowels and pins. End-to-end connections are close-fitting splices of the interlocking type, made by means of offset prongs formed in the strip itself. This important detail makes setting rigid and accurate, with true alignment at top edges.

Expansion Joints

For transverse expansion joints we furnish both the familiar pre-molded asphaltic composition joint and the newer air-cushion type of joint with or without bar doweling provisions. The latter joints are increasingly important items of highway practice and special service is available dealing with the individual specifications of the various states.

Welded Wire Fabric

This welded steel-wire fabric is made to meet any specifications. It is fabricated from cold-drawn wire with each intersection securely welded. Simple and easy to install, it has long been a favorite among road contractors.

Steel Reinforcing Bars

Deformed bars of constant section, rolled from new-billet steel or re-rolled rail steel to section areas conforming to Simplified Practice Recommendation R-26-30 of the U. S. Department of Commerce. These are always available for immediate shipment.

Bethlehem Steel Sheet Piling

For cofferdams and other applications in connection with the building of highway bridges.

Miscellaneous Products

Dowels; Dowel Bar Supports; Marginal Bar Supports; Spacers slab-concrete; Expansion Tubes; Bar Ties; Pins; and Accessories.

A. LESCHEN & SONS ROPE COMPANY

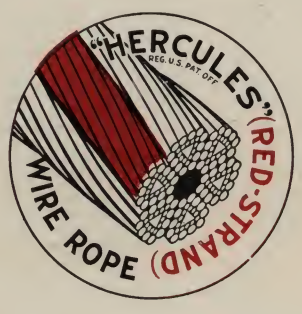
Established 1857

High-Grade Wire Rope for All Purposes — Guard Rail Rope

5909 Kennerly Avenue, St. Louis, Mo.

New York.....90 West Street Denver.....1554 Wazee Street
Chicago...810 W. Washington Blvd. San Francisco.....520 Fourth Street

Products: *"HERCULES" (Red-Strand) WIRE ROPE FOR USE ON CABLEWAYS, CONCRETE MIXERS, CRANES, DERRICKS, EXCAVATORS, HOISTS, SHOVELS AND ALL OTHER TYPES OF HEAVY DUTY MATERIAL HANDLING EQUIPMENT: ALSO GALVANIZED GUARD RAIL ROPE; PLOW STEEL ROPE; *"SPECIAL STEEL" ROPE; CAST STEEL ROPE; WIRE ROPE FITTINGS.



Details of Quality: In the design and manufacture of "HERCULES" (Red-Strand) Wire Rope our first consideration is to produce a product that will be dependable, long lasting and economical under present day working conditions. Some of the chief reasons for its exceptional quality are:

(1) It is made of acid open-hearth steel wire.

(2) Every wire put into this rope is first rigidly tested by us to make sure that it measures up to our exacting requirements, which call for strength, toughness, elasticity and wearing ability in properly balanced proportions.

(3) Our special manufacturing methods and machines insure even tension in both the wires and the strands.

Constructions: In order to be suitable for all conditions "HERCULES" (Red-Strand) Wire Rope is made in a wide range of constructions including numerous designs of Round Strand, Flattened Strand, Non-Rotating, Preformed and Steel Clad types.

Flattened Strand Construction *(P. F. S.): This is a type of wire rope that has decided advantages in points of strength, wearing ability and resistance to crushing. For general hoisting purposes either "Style B" or "Style G" is furnished, the latter being the more flexible. This construction is especially suited for cranes, clamshell buckets, dredges, excavators and shovels. For some purposes it is furnished with a wire rope center instead of the standard hemp center.

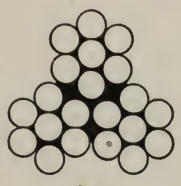
Round Strand Construction: The usual round strand constructions for use on road building equipment are the 6x19, 6x37 and 8x19. We can furnish these constructions in all grades, but "HERCULES" (Red-Strand) Wire Rope is recommended.

Trade No. 500: For some conditions it is advisable to preform the wires and strands in a wire rope. Our designation for this process is Trade No. 500, and it can be applied to various constructions. We would suggest that before adopting this type of wire rope, our Engineering Department be consulted as to its suitability for the work or equipment under consideration.

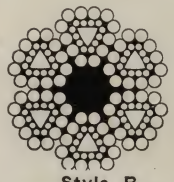
Standard Grades: We also make Plow Steel, "Special Steel," and Cast Steel Wire Rope and our standards are set high in order to make each grade of Leschen Wire Rope the very best that can be produced in its particular grade.

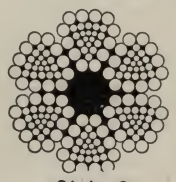
Guard Rail Cable: This is made of 3 strands of 7 wires each, and is always furnished galvanized. It is made to meet the specifications of all State Highway Departments.

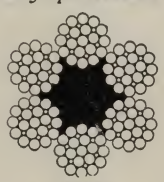
Consult Us on Wire Rope: It is highly important to use the kind of wire rope that will fit your working conditions. If you will tell us how you use wire rope we shall be glad to suggest the right construction for best results.

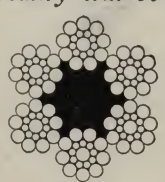

3x7
Guard Cable

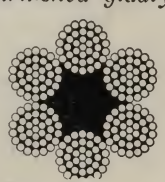
Leschen Wire Rope is stocked at over 100 different points. The name of our Distributor in any particular locality will be furnished gladly upon request.

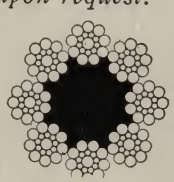

Style B
Flattened Strand

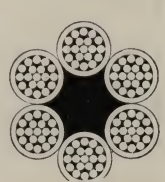

Style G
Flattened Strand


6x19
Filler Wire


6x19
Seale


6x37
Extra Flexible


8x19
Extra Flexible


6x19
Steel Clad

The above illustrations, except the one marked "Guard Cable," show different constructions in which "HERCULES" (Red-Strand) Wire Rope is furnished for use on various types of road building equipment. For some conditions a wire rope center is furnished instead of the standard hemp center.

*Reg. U. S. Pat. Off.

LINK-BELT COMPANY

Chicago Works—Crane and Shovel Division—300 West Pershing Road

Other Plants at Philadelphia, Indianapolis, San Francisco and Toronto. Distributors and Offices in All Principal Coties.

PRODUCTS: Crawler Shovels—Cranes, Draglines; Locomotive Cranes; Crawler Bucket Loaders; Portable Conveyors, Belt, Chain and Flight Types; Elevators and Conveyors of All Types and for Every Purpose; Central Concrete Mixing Plant Equipment; Sand, Stone, Gravel, Cement, Lime Plant Equipment; Positive Power Transmission Machinery & Chains of All Types—Silent, Roller, Malleable, Promal, Steel.

The Link-Belt Shovel—Crane—Dragline

¾ to 2½ Cu. Yd. Capacities

Based on performance—the Link-Belt shovel-crane-drag-line is a "low-cost" machine—a combination of features in design and construction that make for heavy-duty service—greater capacity —greater endurance—dependable performance—less interruption in service—longer lived parts—fewer repairs—less upkeep.

A truly "built for service" machine that can be used, with equal facility and full efficiency, with dipper shovel, trench shovel, crane and dragline boom, skimmer scoop, backfiller board, pile driver, lifting magnet, etc.; and can easily and quickly be converted from one to another without changing or disturbing the body of the machine.

In the one machine you have the full advantage of many; to perform your work in whatever manner it can be done most effectively and economically.

These machines are built up to 2½ cu. yds. capacity for hard, heavy digging, and all of them may be shipped assembled, on flat cars. Simply run the machine off the car and it is ready to go to work Hundreds of dollars are saved every time the machine is shipped from place to place, by eliminating the partial dismantling required in most machines of these sizes.

Machines are furnished with gasoline or Diesel engine or electric motor drive, as required.

Send for catalogs.



4735-A



One of Morrison-Knudsen, McDonald and Kahn's two Link-Belt shovels on the Ridge Road Alternate job (California). Every mile of grading on this road was tough going, involving big fills, deep cuts, channel changes, and slides. One cut in Section 1 is said to be the biggest in the history of road building in the U. S.



Link-Belt shovel working at an elevation of 9,000 ft., for Robinson-Roberts Co., Los Angeles contractors, on a California highway. Link-Belts have that extra engine power required for work in high altitudes such as this, where the loss in power approximates 28 per cent.



Link-Belt Skimmer Scoop excavating to a depth of about eight inches of lime rock. One thrust of the bucket cuts to grade, the machine being built for the hardest kind of service. This permits the utilizing of the full power of the motor, so as to most effectively overcome impediments in the form of rocks, strata of hard material, stumps, etc., which are common to skimmer scoop work.

Link-Belt dragline and belt conveyor equipment engaged in changing the channel of a river. Dirt excavated by means of draglines, discharges to a bridge mounted swinging boom belt conveyor, which delivers it to any desired point. This equipment is establishing new low-cost yardage records.

MACASPHALT CORPORATION OF AMERICA

34-03 Lawrence Street
FLUSHING, N. Y., U. S. A.

MACASPHALT

Registered U. S. Patent Office

Laboratory:
34-03 Lawrence Street,
Flushing, New York.

Licensees:
Macasphalt Corporation of Florida,
Lakeland, Florida.

Macasphalt Corporation of Georgia,
884 Glenwood Avenue, S. E.,
Atlanta, Ga.

Macasphalt Corporation of New Jersey
Bogota, New Jersey

Clinton Asphalt Company,
308—16th Street, Union City, N. J.

Macasphalt Corporation of Illinois
111 West Washington Street,
Chicago, Ill.

Cables: Macasfalt, Flushing, N. Y.
Telephone: Flushing 9-7577
Licensees:

The Toledo Macasphalt Corporation,
Hill Avenue and City Limits,
Toledo, Ohio.

Wm. P. McDonald Construction Co.,
34-03 Lawrence Street
Flushing, New York

Macasphalt Corporation of Massachusetts
910 Huntington Avenue,
Boston, Mass.

Foreign Representatives:
McDonald International Corp.,
34-03 Lawrence Street
Flushing, N. Y., U. S. A.

Macasphalt, Ltd.,
2020 Union Avenue,
Montreal, Quebec.

MACASPHALT is a *Standard Bituminous Paving Material in a More Convenient Form, manufactured hot but laid cold.*

Reasons Why It Pays to Build With

MACASPHALT

Most durable
Quickly laid
No detours
Impermeable
Smoothest riding
Positively non-skid
Most economical
Local workmen

Macasphalt is not produced with a cut back or emulsified material but is composed of proportioned quantities of mineral filler, selected and graded stone or sand aggregates and **Macasphalt Cement.**

Macasphalt, unlike other forms of bituminous pavements, is **non-skid,** providing a granular surface to traffic that is not artificially produced by the use of large stone at the surface. Macasphalt is unique in this particular, the non-skid quality being inherent in the pavement and produced by the very nature of the carefully prepared **Macasphalt Cement.**

Macasphalt may be transported and **laid cold** at ordinary air temperature. It may be shipped by rail or hauled by trucks, and requires no heating to unload. It may be **stored** for an **indefinite period** without affecting its workability and without injury to its efficiency as a pavement, and it is at all times ready for immediate use.

Macasphalt is used for new construction, for resurfacing any type of existing pavement and for maintenance and repairs. No binder course is necessary when foundation is true to grade and cross section, due to the peculiar plastic and adhesive qualities of the mixture.

One of the outstanding and economical features of Macasphalt is that skilled labor is not required in laying the pavement.

Build with Macasphalt and Employ Local Labor

RIGHTS TO MANUFACTURE: We have available territory in which we will license responsible Quarrymen, Contractors and others interested in establishing plants for the manufacture of MACASPHALT. Information regarding same can be secured by applying to the Macasphalt Corporation of America.

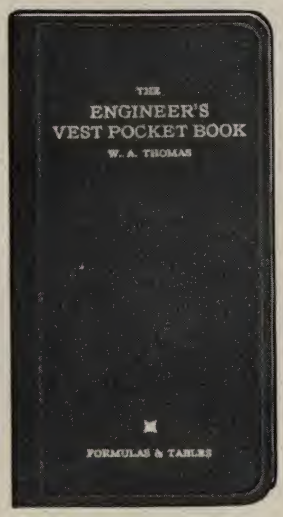
WHEN YOU NEED IT MOST..

A handy, compact source of reference for practically all engineering problems in the field or at the office.

The Engineer's Vest Pocket Book

by

W. A. THOMAS,
Consulting Engineer



12
MAIN DIVISIONS

Mathematics, Statics and Dynamics, Strength of Materials, Bldg. Construction, Mechanical Design, Heat, Hydraulics, Chemistry and Physics, Electrics, Transportation, Surveying, Costs and General Classified Directory.

The scope of this book is almost incredible. Regardless of the branch of engineering you follow, you will find it an invaluable source of reference, and its clear, compact arrangement will win your instant approval.

Formulas are given which meet nearly every kind of engineering problem, and the generous tables and diagrams are helpful in providing short cuts.

See it for yourself and judge its value to you. Send no money. Just fill in the coupon.

Ten Days' Free Examination

USE ORDER CARD NO. 3
on Page 137
when requesting your copy of this book.

GILLETTE PUBLISHING CO.
400 W. Madison St. Chicago, Ill.

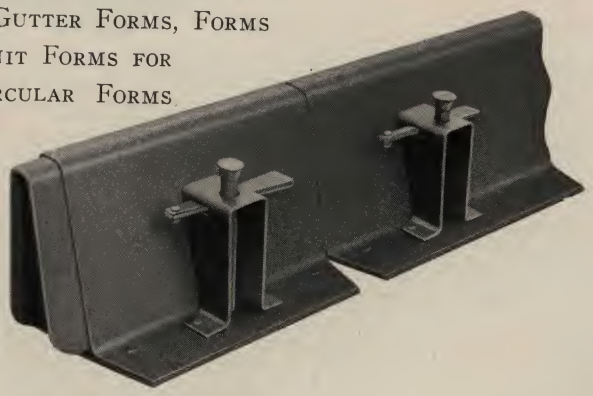
METAL FORMS CORPORATION

3334-3343 North Booth Street, Milwaukee, Wisconsin

Manufacturers of Metal Forms for Concrete Construction

METAFORMS ROAD RAILS

Products: Metaforms Road Rails, Integral and Lip Curb Forms, Curb and Gutter Forms, Forms for Concrete Manholes, Unit Forms for Concrete Construction, Circular Forms for Coal Pockets, Silos, Grain Elevators, Oil Reservoirs, Settling Tanks, etc.



Engineered to Endure

Metaforms Road Rails: The most economical side forms are those with which you can lay the greatest mileage of pavement, satisfactory to close inspection, during their working life. Because its design and the material from which it is fabricated make it more rigid and enduring than any other side form obtainable, the Metaforms Road Rails should have your first and very thorough consideration.

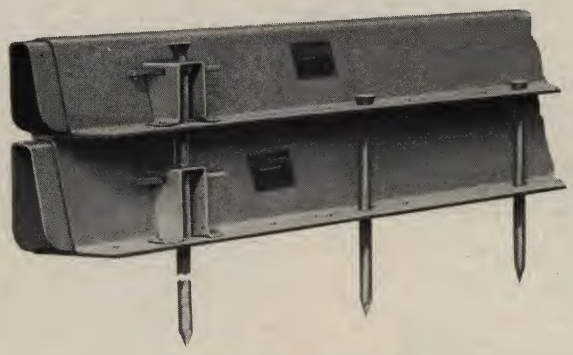
The Metaform complete arch, wide base design, using 10 Ga. plus, special Carbon, blue annealed steel, was designed to provide the utmost rigidity and strength under the sidewise thrust of compacted concrete, and the weight and battering of the finishing machine.

Metaforms are furnished in 6″ height, 6″ base, 7″ height, 7″ base, and 8″, 9″, 10″, 11″ and 12″ heights with 8″ base and a 9″ height rail with a 9″ base. Other heights to specifications.

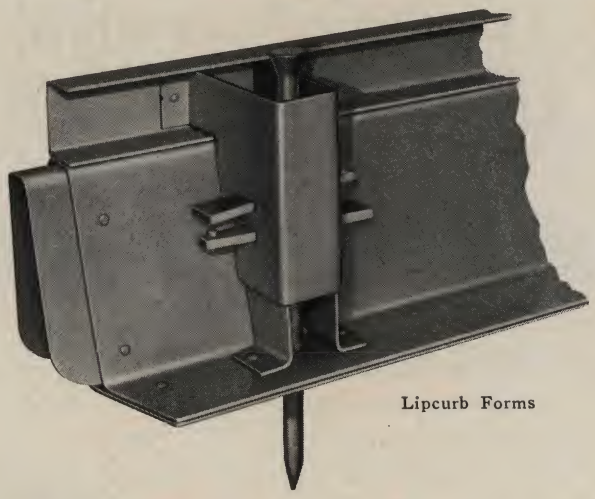
A continuous, heavy steel web forms a complete arch with a bracing slope on the outside leg and the two web ends meet at the base of the outside leg to form the wide flange where they are heavily riveted together. Instead of a single vertical steel web supporting the finishing machine, its weight is divided between two complete webs formed into an arch—the most rigid type of design known to engineers. Those two webs are in turn braced, not only by the firm riveting of the flange or base, but by heavy stake boxes at either end of the ten-foot rail. No more rigid design could be given a road rail than is utilized in fabricating Metaforms Road Rail. They are absolutely dependable under the most severe conditions.



Lip Curb Metaforms: To place a Metaforms Lip Curb rail in place it is necessary only to put the Lip Curb Header box down over the rail stake box, drive the stake home through the two boxes and clamp them to the stake by means of the regular attached stake clamps. Lip Curb Metaforms can be used with any new or old Metaforms Road Rail. They are made in 2″, 3″, 4″, 5″, and 6″ heights, all in 10-foot lengths. These Lip Curb Metaforms save so much time and do so much better work than any other method of forming a Lip Curb that they are quickly paid for on any paving job, by the saving they make.



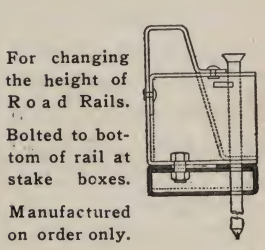
Metaforms for Curb Work



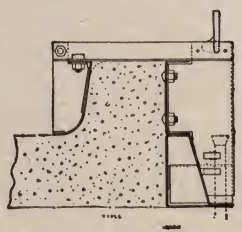
Lipcurb Forms

Back Rails for Curb Work: Where a curb is to be built along a pavement laid with Metaforms Road Rails, it may be formed to best advantage by placing one Metaform rail atop another to secure the required height, and staking both rails with the same Metaforms steel stakes, as is shown in our illustration. The face of this curb work presents the fine appearance desired by every contractor.

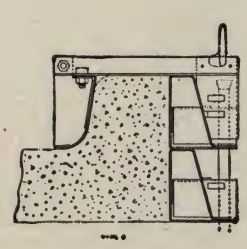
Curb and Gutter Metaforms are designed to form practically every type of curb and gutter required. The one type illustrated on this page shows the four units of a Metaforms assembly: the front and back rails, the



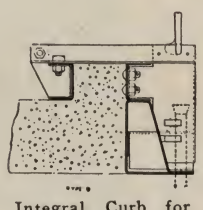
For changing the height of Road Rails. Bolted to bottom of rail at stake boxes. Manufactured on order only.



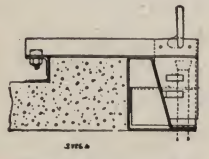
Integral Curb with Header Back Rail



Integral Curb using two Metaform Standard Rails



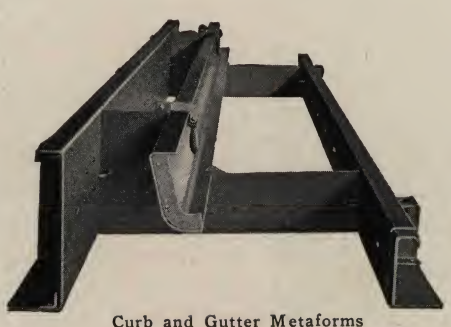
Integral Curb for Brick or Block Surfacing



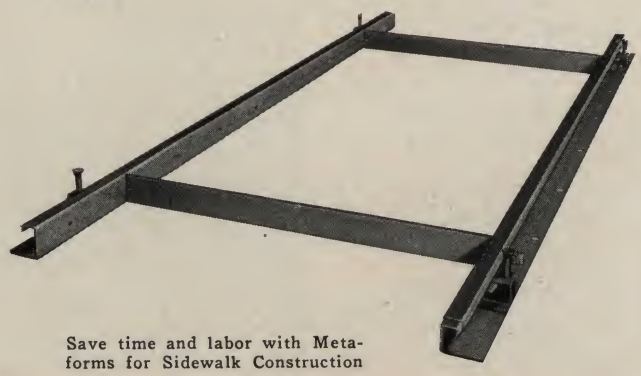
Integral Curb for Bitulithic Surfacing

should be formed with the face rail of the Integral Curb set-up as is illustrated on this page. This is the fastest, lowest cost method of building such curbs.

Integral Curb Metaforms: Illustrated on this page are several methods of forming integral curbs with Integral Curb Metaforms for use with Metaforms Rails. All Integral Curb Metaforms are separate units made to fit all standard Metaforms Road Rails. Where integral curbs are required, these forms provide the simplest, easiest, lowest cost method of forming them, and the resulting division plates and the face rail. Division plates are locked in place with hooked clamps engaging them through slots in the front and back rails. The face rail is formed with either a single or double radius and is held in position by hooking the lower edge under hook-projections on the division plates and by clamping the top of the face rail to the top of the division plate. The face rail cannot float with rising concrete or budge while concrete is being tamped or poured.



Curb and Gutter Metaforms



Save time and labor with Metaforms for Sidewalk Construction

MEXPET ASPHALT PRODUCTS

INDUSTRIAL

Roofing Saturant
Roofing Compound
Roofing Coating
Roofing Cement
Roofing Flux
Waterproofing Asphalt
Paper Asphaltum

PAVING

Binders
Cements
Cutbacks
Fillers
Road Oils
Liquid Asphalt
Surfacing Asphalt



Plant Mixed Asphaltic Pavement on West Executive Avenue, Washington, D. C., where MEXPET ASPHALT was used

The use of Mexpet Asphalt on this principal avenue of the best paved city in the country was not accidental, as it was especially selected for this job.

FOR INFORMATION, communicate with

MEXICAN PETROLEUM CORPORATION

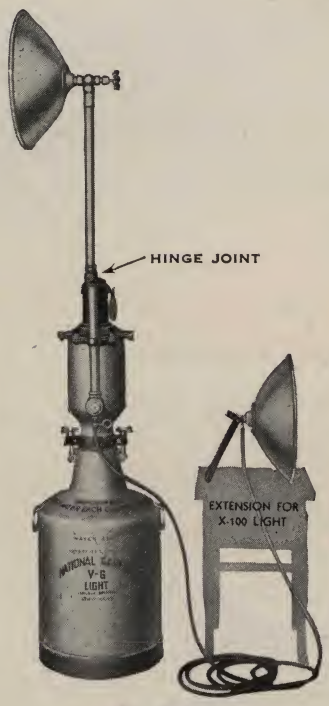
122 East 42nd Street
NEW YORK

ATLANTA, GA.

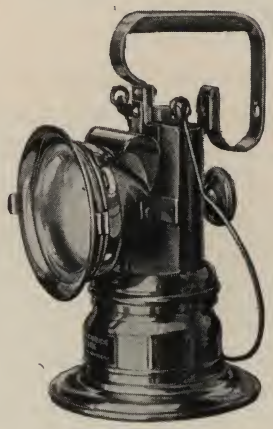
NEW ORLEANS, LA.

NATIONAL CARBIDE SALES CORPORATION

LINCOLN BUILDING, NEW YORK, N. Y.



No. X-100



No. WL I-CI



No. Y-199

National Carbide Lights

The National Carbon V-G Light

Spreads a full, even beam of about 8,000 candlepower right where you need it. Simple in construction without anything to get out of order, it gives ample clear, steady light for about twelve hours on one 7-pound charge of National 14-ND Carbide and 7 gallons of water. Easily handled by one man. Weight 35 pounds empty, 98 pounds when full. No harm done if it tips over:—simply stand it up, and it goes right on working.
Reflector standpipe may be tilted to any angle.

PRICE: Without Extension $48.00
Extension, $8.00
F. O. B. Williamsport, Pa.

The National Carbide Lantern

Is the nearest approach to daylight ever found in a lantern—giving ten times more light than an oil lantern, and at less cost. It is sturdily constructed, with convenient handle and extra bail for carrying on the arm. Easily filled. Easily lighted. Burns eight hours on a single 8-ounce charge of Carbide and one filling of the water chamber. A brilliant rear signal of red, blue or green is supplied without extra charge if required.

PRICE: $7.50
F. O. B. Brooklyn, N. Y.

The National Carbide V-G Handy Light

Is a smaller size consisting of a tank holding 2 gallons of water, a hopper containing a 1¾-pound charge of National 14-ND Carbide and the feeding device. It runs for approximately five and one-half hours on one 1¾-pound charge of carbide and one 2-gallon charge of water and delivers about 1500 candlepower. It is a most handy light to use for emergencies as it is so easily carried around. Weight only 37 pounds when charged. Reflector may be tilted to any angle.

PRICE: $30.00
F. O. B. Williamsport, Pa.

The V-G lights can be shut off at any stage of the charge and allowed to stand for a day or a month, and then put into instant operation without wasting a particle of carbide.



The Red Drum
Saves You Money

Portable Daylight

You'll welcome this nearest-approach-to-sunlight known—NATIONAL CARBIDE—because by getting daylight conditions on your night jobs and underground work, you increase the speed and efficiency of your workers.

NATIONAL CARBIDE is available everywhere—always packed in the red drum—with NATIONAL CARBIDE warehouses and distributors from coast to coast.

NATIONAL CARBIDE SALES CORPORATION
Lincoln Building, New York, N. Y.

VITRIFIED BRICK PAVEMENTS

For Paving Highways, Streets, Alleys, Drives, Etc.

For additional Information write
National Paving Brick Association
1245 National Press Building
Washington, D. C.

Characteristics: Vitrified brick pavements are known for their long life and low upkeep costs. Pavements of brick laid during the time of Napoleon Bonaparte are still in use in Holland, while in the United States there are numerous pavements of this type in active service for more than 40 years.



Brick resurfacing on worn pavement as completed on more than 120 miles of Illinois state highways by the Illinois State Highway Department. Other states have initiated similar prog ams.

Other features of vitrified brick pavements that make it popular are: (1) its ease of construction; (2) certainty of a durable pavement of easy riding qualities; (3) no need for expensive equipment to make repairs if and when needed; (4) ease with which service cuts may be made and replaced for underground utility pipes, cables, etc.

Reason for Long Life: Brick pavements offer a maximum of protection against **weather** as well as traffic. Vitrified brick being non-absorbent, are not affected by freezing. Temperature changes are compensated by asphalt filler between bricks, hence no cracking. Brick are laid in a sand cushion which absorbs heavy shock. Being of dense, hard structure, brick surfaces do not soften in sun and rut from vehicular traffic.

Details of Construction: Brick pavement surfaces are used in connection with a variety of different types of bases. Illustrated booklets will be forwarded free of cost to all interested in the subject.

Resurfacing: Where slab pavement needs resurfacing to prevent destruction and give good traffic surface, brick surfaces are recommended as giving highest type job at low cost. *See illustration above.*

Low Upkeep Costs: *Example No. 1.* A test road embodying several different types of construction, including vitrified brick, was completed over 20 years ago by the United States Bureau of Public Roads, Washington, D. C. Accurate upkeep costs have been kept, the figures on same taken from government records for a twelve year period when traffic conditions were truly comparable. **The upkeep on brick was 2.86c per sq. yd. Other common types showed upkeep costs ranging from 2 to 30 times greater.**

Example No. 2. Buffalo, N. Y., is noted for the accuracy of its records on upkeep cost of its different types of streets, as kept by the Department of Public Works, Department of Engineering. Figures from the latest report on brick pavements more than 10 years old are as follows: 1919-1920—$0.0249 per sq. yd.; 1920-1921—$0.0171; 1921-1922—$0.0204; 1922-1923—$0.0158; 1923-1924—$0.0133; 1924-1925—$0.0229; 1925-1926—$0.0397; 1927—$0.0024; 1928—$0.0099; yearly average—$0.0185. **Brick upkeep was by far less than for other types.**

Brick Streets in Use 30 Years or More: The following cities are typical of a long list that are today using brick pavements laid 30 years or more ago: Norwalk, Ohio, 44 years; Canton, Ohio, 44 years; Jacksonville, Florida, 43 years; Dunkirk, New York, 43; Mt. Pleasant, Pennsylvania, 37; Minneapolis, 35; Evanston, Illinois, 39; Kalamazoo, 36; Cincinnati, 37; Buffalo, New York, 39; Lockport, New York, 41; Detroit, 32; Marion, Ohio, 36; Williamsport, Pennsylvania, 32; Tonawanda, New York, 40; Pana, Illinois, 35; Indianapolis, 34 years; Columbus, Ohio, 44 years.

Salvage Value: Brick pavements have a double wearing surface. After years of wear, the unused side may be turned to the traffic, thereby gaining a new, perfect surface from the original brick. The relaying of brick being a hand-labor operation, it has been a favored project in the Re-employment programs.



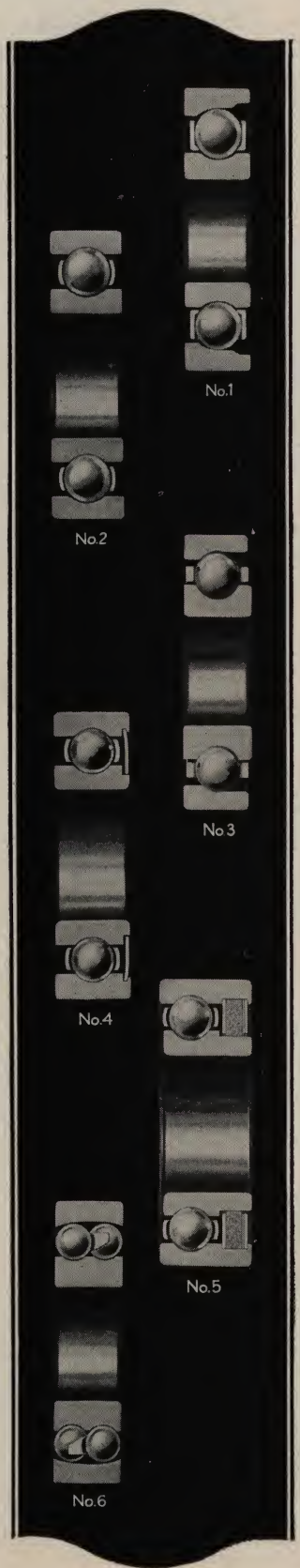
Close-up of brick surface from Connecticut Ave., Experimental Road, Chevy Chase, Md., which was buitl over 20 years ago by the U. S. Bureau of Public Roads. In this test brick has shown the lowest maintenance cost of all pavement types.

NORMA-HOFFMANN BEARINGS CORPORATION

Manufacturers of Precision Bearings for Road Building and Contracting Machinery

Main Office and Factory: STAMFORD, CONN., U. S. A.

Detroit Cleveland Cincinnati New York Chicago Pittsburgh



"NORMA-HOFFMANN" PRECISION BEARINGS

As standards of practice improve, and as engineers and contractors more and more recognize that greater machine dependability means greater profits, **Norma-Hoffmann** Precision Bearings find ever-increasing application in road-building and contracting machinery and equipment of the better class. This acceptance is based upon their proved records for dependable performance and for higher economy longer sustained. They impart an extra stand-up-ability to any equipment of which they are a part—an extra safeguard against breakdown.

Precision Bearings for Every Load, Speed and Duty

No one type of bearing is so versatile in its operating characteristics that it will meet all of the wide diversity of duties in road-building and contracting machinery. From the comprehensive **Norma-Hoffmann** line, however—here illustrated in part, and briefly indexed—a **Precision Bearing,** or several in combination, can be chosen that will satisfy almost any conditions of operation.

1. Open (separable) type ball bearing.
2. Closed radial type ball bearing.
3. Angular contact ball bearing.
4. Single-plate, grease-retaining, dirt-excluding ball bearing; available in double-plate type also.
5. "7000" Series "Greaseal" felt-protected ball bearing; available also with side plate, or with double felt seal, wholly self-enclosed.
6. Double row, self-aligning ball bearing; also furnished with adapter sleeve and nut.
7. Standard cylindrical roller bearing.
8. One-lipped cylindrical roller bearing.
9. Two-lipped cylindrical roller bearing.
10. Full type (retaining ring) cylindrical roller bearing.
11. Self-aligning adapter type cylindrical roller bearing, with grease-retaining, dust-and-moisture-excluding side plates.
12. Ball thrust bearing.

Engineering Service and Publications

If the utmost is to be realized from the use of anti-friction bearings, they must not only be carefully chosen as to size and type, but must also be properly mounted and lubricated. Therefore, in applying **Precision** Bearings to your own machines—either as a specified part of new equipment, or for replacement or change-over in old equipment—let our engineers assist you with their highly specialized experience in bearing applications. This advisory service insures no obligation, yet assures your satisfaction. Let us send you the Catalog of **Precision** Bearings, with engineering data.



PAGE STEEL AND WIRE DIVISION

OF

AMERICAN CHAIN COMPANY, Inc.

General Sales Office and Plant: MONESSEN, PA.

Manufacturers of PAGE TRAFFIC TAPE

(Reg. U. S. Pat. Off.)

District Offices: Atlanta, Chicago, New York, Pittsburgh, San Francisco

TRADE-MARK
America's first wire fence-1883

An Associate Company of the American Chain Company, Inc.

Until Page Traffic was developed, no guard had been offered which was suitable for installation under all road conditions and in all localities.

PAGE *traffic* TAPE

NOW—Page Engineers announce the result of many years of research—a progressive contribution to highway protection — Page Traffic Tape.

MAJOR POINTS OF SUPERIORITY

SAFETY

1. **Higher Tensile Strength** because there are 21 parallel wires running continuously throughout the tape—the same number and the same size wires as used in standard ¾-inch highway cable. In Page Traffic Tape these wires are stronger, due to elimination of helical twist.

2. **Reduced Damage** to vehicle because of the greater area at point of contact. **Vehicle Stops Gradually** because tape is flexible in plane parallel to the ground.

3. Sturdy Off-Set Fittings **Reduces Danger of Posts Breaking** thru contact with vehicle.

4. **Better Visibility** because of a silvery surface 2½ inches wide which is visible by day or night.

ECONOMY

1. A hot-galvanized finish on Page Traffic Tape provides **Adequate Protection from Corrosion.** It is unnecessary to paint Page Traffic Tape, but when it is painted for even greater visibility the flat surface of the tape can be covered easily and quickly.

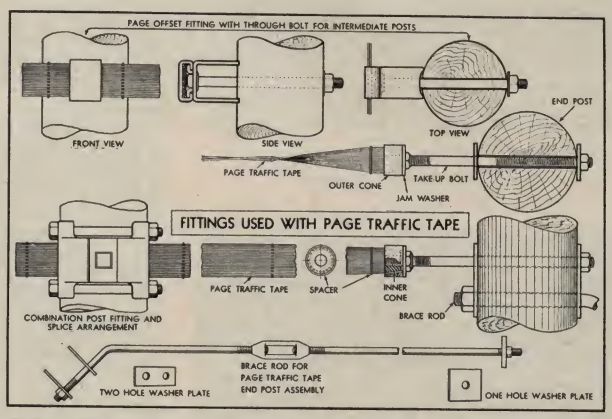
2. Page Traffic Tape **does not constitute a snow removal barrier.**

3. **It can be stretched on existing posts,** either round or square without changes.

4. **Less Sagging** because the tape is comparatively rigid in the plane verticle to the ground.

ERECTION

Page Traffic Tape is erected easily and speedily in the same manner as cable. The tape is unreeled, cut, anchored and stretched. Page Off-Set fittings are used for attaching the tape to the line posts. It can be used easily to replace wood or cable on existing posts.



The above illustration shows the few fittings required with Page Traffic Tape. Offset post fitting and anchor rods are steel—end clamps are malleable iron with steel bolts.

FITTINGS

Page Traffic Tape is regularly shipped on wood reels, each carrying approximately 2,500 feet of tape. Weight approximately 87 pounds per 100 lineal feet.

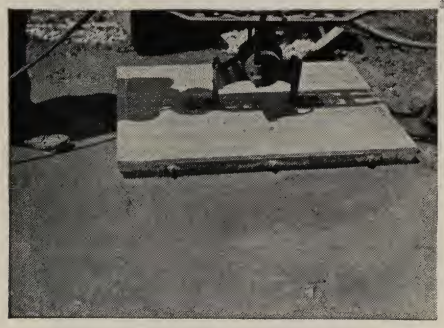


ELMHURST TEST ROAD



General View—Cement Bound Macadam Test Road at Elmhurst, Ill. Finished sections at left background. Coarse aggregate in foreground being given initial rolling with 3-ton tandem roller.

For Light Traffic both Roads and Streets and widening jobs—use Cement Bound Macadam built with CWA Labor!



Vibratory platform used for compacting some of the sections.



Vibratory screed used for compacting certain sections.

PRODUCES THE ANSWER . . . CEMENT BOUND MACADAM

81 sections of Cement Bound Macadam Pavement were built, providing the opportunity to study the action and results of 81 combinations of material and methods, under completely controlled conditions—years of experience gained in a single season.

AGGREGATES USED:

CRUSHED LIMESTONE
GRADED GRAVEL
AIR-COOLED, BLAST FURNACE SLAG
COARSE, MEDIUM AND FINE SANDS

METHODS OF COMPACTING:

HAND TAMPING
TANDEM ROLLERS, LIGHT AND MEDIUM
VIBRATORY SCREEDS
VIBRATORY PLATFORMS



Test beam removed for determination of flexural strength. The rough surface is the bottom, or sub-grade side of the pavement slab.

Sub-grade treatment was studied. Methods of applying grout and the effect of varying consistencies of grout were thoroughly tested.

Results were checked by removing full size beams from the slabs and testing them in flexure: cores were taken for compressive strength tests.

The results were most convincing—you see some of them here—they will be available soon in booklet form. Write for your copy now.

Meantime here is another low cost way of building a rigid, permanent pavement.

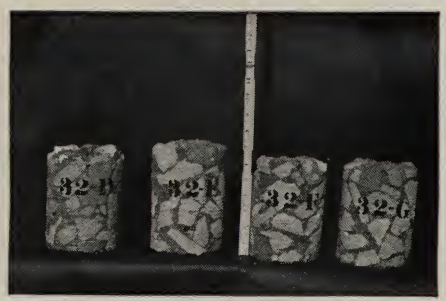


"Flow cone" developed for measuring the fluidity of grout.

"Flow cone" in use in the field.



The edge of a ten-inch slab; uncrushed gravel aggregate, fully penetrated by grout.



Cores removed for determination of compressive strength, from one of the sections built with crushed limestone aggregate. Note complete penetration of grout.

PORTLAND CEMENT ASSOCIATION

Room 42 —33 West Grand Avenue, Chicago, Illinois

W. A. Riddell Company BUCYRUS OHIO



Modernized for the New Deal N.R.A. Manufactured

WARCO Power Controlled Rear Control Grader such as is shown in accompanying illustration is a leader in Highway construction and maintenance. Their rugged construction, ease of operation and superior design have created many satisfied users. The famous WARCO Screw Lift is standard equipment on all WARCO Rear Control Graders. Can also be furnished with manual controls in place of power control.

These machines can be furnished on pneumatic tired wheels with the desired brand of tires, or on our Octopus 8 or 4 Wheel Oscillating Tandem Drive with pneumatic or zero pressure tires.

WARCO Graders can be furnished in both center and rear control models powered with McCormick-Deering Model 20, I-30 and Model 30; J. I. Case Models CI and LI; Oliver-Hart-Parr 18-28 and 28-44 Tractors. With our facilities, adaption to tractors of other makes can be easily and quickly made. All WARCO Power Graders are built with sturdy I-beam frames formed on a true radius giving the grader a symmetrical appearance and distributing the stress throughout the entire frame instead of centralizing the stress at some sharp or moderately sharp bend. All attachments to the frame are securely bolted to the web of the I-Beams; no holes are driven into the I-Beam flanges. WARCO patented head type steering gear designed particularly to meet power grader requirements is standard equipment on all models—WARCO Screw Lift Blade Lifting Mechanism is standard equipment on either Power or Manual Control rear controlled graders.

The new WARCO Pull Type Grader is not "just another pull grader" but can truly be said to be an exceptional grader with exceptional features. A heavy tubular frame forms the backbone of the grader which permits swinging the blade into actual vertical position. This feature together with the leaning wheels and laterally shifting rear axle makes ditch cutting and bank sloping a simple operation without the necessity of a bank sloping attachment. These Pull Graders can be fitted with our heavy duty scarifiers which attachment can be installed or taken off in the field.

WARCO Heavy Duty, Tubular Frame, High Lift Graders are built in two sizes called the "Big and Little Bertha" respectively and accommodate from 8 to 14 foot moldboards.



WARCO Drawn Graders Are Sturdily Constructed for Tough Going

ROBESON PROCESS COMPANY

GENERAL OFFICES:
230 PARK AVENUE, NEW YORK CITY

OPERATING PLANTS:
Au Sable Forks, New York and Erie, Pennsylvania

PRODUCT—Glutrin Road Binder for Gravel and Sand Clay Roads.

GLUTRIN ROAD BINDER

As a Binder for Clay-Gravel Roads and Gravel Shoulders of Concrete Roads, Glutrin Road Binder is unsurpassed. It produces an even, dustless and hard surface that assures long life and good traction, thereby reducing the tendency of skidding, as compared with other types of roads.

A Glutrin bound road or shoulder is easily and economically repaired, thus insuring low maintenance costs. Furthermore, it is not affected by frost, which usually necessitates extensive repairs in the Spring of the year, on roads or shoulders not treated with Glutrin.

ROBESON PROCESS COMPANY

— General Office —

230 PARK AVENUE NEW YORK CITY

SAUERMAN BROS., Inc.

482 S. Clinton St., Chicago

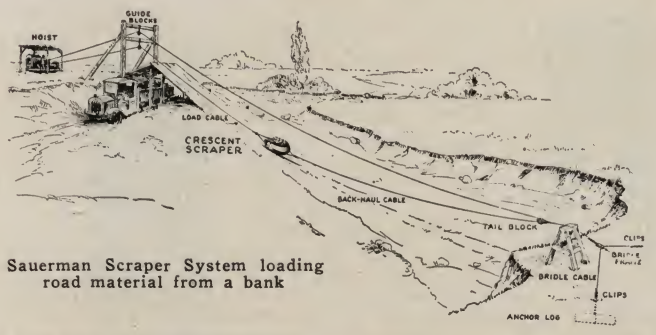
PRODUCTS—Drag Scraper Systems, Slackline Cableway Excavators, Tractor-Drawn Scrapers, Crescent Buckets, Scraper and Cableway Hoists, Durolite Sheave Blocks, Etc.

Sauerman Drag Scraper Systems

The Sauerman Drag Scraper System consists essentially of a bottomless scraper bucket that is dragged back and forth over the ground by means of two cables operated by a double-drum power unit. Only one man is required for its operation, and as the bucket is bottomless it digs its own load automatically when pulled forward, and discharges its load automatically when pulled back from the dumping point.

The Crescent scraper bucket, which is an exclusive feature of Sauerman Scraper Systems, possesses a unique plow-share-like design, which gives it maximum penetrating power with minimum weight. When loaded, the scraper rides the surface of the material, carrying the load to the dumping point with minimum effort.

There are numerous variations in Sauerman Scraper Systems to adapt the equipment to the requirements of different work. Bucket sizes range from ⅓ to 15 cu. yd., operating spans from 200 to 1,000 ft., and hourly handling capacities from 10 to 600 cu. yd. For complete details, write for Catalog No. 16.

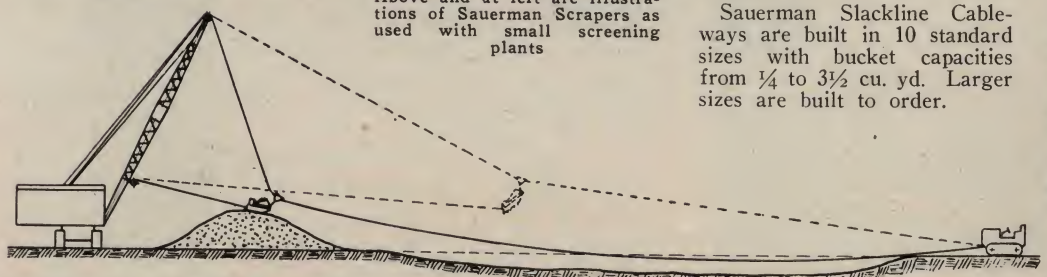


Sauerman Scraper System loading road material from a bank





Above and at left are illustrations of Sauerman Scrapers as used with small screening plants



Crescent bucket can be provided with a carrier and rigged up as shown above to give a crane several hundred feet of additional reach

Crescent Hydraulic Scrapers

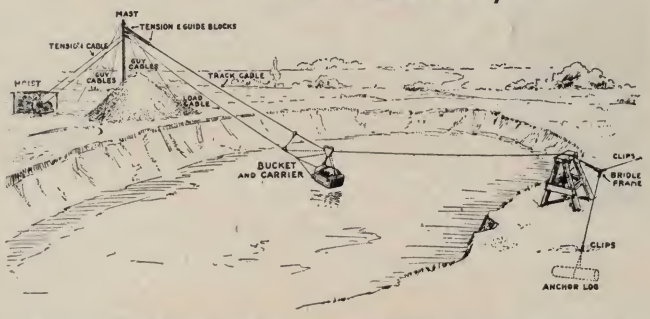


Crescent Hydraulic Scraper

The Crescent Hydraulic Scraper, operated by a tractor, is a very economical tool for cut and fill work, highway grading, ditching, etc.

The scraper is attached (by a "Universal" coupling) to the drawbar of the tractor, and is equipped with a hydraulic ram, which is actuated by oil pressure from a simple geared pump bolted to the flange of the power take-off on the tractor. The tractor driver controls the loading and dumping of the scraper through a control valve located at his right hand.

Sauerman Slackline Cableways



Sauerman Slackline Cableway moving gravel from under water onto a storage pile

A Sauerman Slackline Cableway performs the triple service of digger, conveyor and elevator in moving material from a pit, river, pond, etc., to a screening plant, spoil pile or storage bin. It will dig to a depth of several hundred feet (either in dry ground or under water), haul the excavated material any distance up to 1,200 ft. and dump the material automatically at an elevated delivery point. The excavator bucket is attached to a carrier which travels on an inclined track cable, and after the bucket dumps its load it returns by gravity to the digging point. A bucket will make from 25 to 50 trips per hour, the time required for a cycle of operation varying in accordance with differences in length of haul and digging conditions.

Sauerman Slackline Cableways are built in 10 standard sizes with bucket capacities from ¼ to 3½ cu. yd. Larger sizes are built to order.



Cableway lifts gravel to top of screening plant

SERVICISED PRODUCTS CORPORATION

Telephone Grove Hill 0423

MANUFACTURERS AND ENGINEERS

6051 W. 65th St., Clearing Station, Chicago, Ill.

DISTRIBUTORS AND DEALERS IN PRINCIPAL TRADING CENTERS

FACTORIES AND SALES OFFICES: Wilmington, Delaware; Chicago, Ill.

Products: Preformed Asphalt Waterproofing Sheets; Rail Filler; Highway Crossing; Expansion Joints for Paving or Building Purposes; Sewer Pipe Joints; Bridge Flooring; Industrial Flooring.



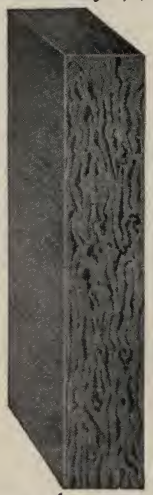
Servicised Expansion Joints are prepared in mastic form with felt sides, sponge rubber cork and caneboard saturated. They are used to take up expansion contraction, monolythic constructions insuring against damage due to causes of change in temperature.

Servicised Expansion Joints have been on the market since 1922, and are being used in every state of the Union.

These Joints are safety strips comprising bituminous material and interlocking linear fiber, fabricated into convenient shapes which come to the job ready for use and as readily handled as a board.

Reinforced Expansion Joint

Servicised Reinforced Expansion Joint is a superior premoulded product developed for use where extra rigidity and strength is desirable, as where only ¼ inch or ⅜ inch fillers are installed.



The core consists of an asphalt-fiber mixture resembling Type "B" Servicised material closely, the variation being in the quantity of asphalt present, a greater amount being necessary to make up the deficiency in the saturated felt.

Increased rigidity is attained by reinforcing on either side by strips of saturated felt, cemented to the core. In this way, the resiliency and correct functioning of Type B structure is preserved, with reinforcing as an added feature.

Type "B" Expansion Joints

For general use in concrete construction, wherever premoulded filler and expansion materials are permitted, advantageous or specified. They are formed under pressure from an homogeneous mixture of high quality asphalt and specially selected saturated fiber rolled into parallel mats that impart great resistance, flexibility and toughness to the joint. Thus an unusual conformity to expansion and contraction movements is secured together with long elastic life and maximum control of oozing.

Sponge Rubber Expansion Joint prepared by **Servicised** has met all requirements under the various specifications, and has given lasting satisfaction wherever used. This type of material has come into considerable use in those states where an expansion joint which does not extrude from the pavement is required. It is composed of sponge rubber having thousands of tiny air cells incorporated into it and has the protection of felt sides.

Servicised Cork Compound Joints are prepared with cork granules and a flexible binder and are primarily a Servicised creation.

Servicised Caneboard Joint comprises a structure similar to celotex saturated with a waterproofing material.

Servicised Asphalt Planking and Bridge Flooring

This is a block-like asphaltic structure formed under pressure by extrusion. Uniformly incorporated in the plank are long and short fibers of rag felt and asbestos to give resiliency, and mineral filler to build up strength and resistance to wear.



Servicised Asphalt Planking is furnished in either straight or angle-lap edges.

Servicised Plank makes an improved wearing surface on bridges, viaducts and approaches to them. It is quickly and economically laid under any climatic condition, impervious to water, does not corrugate or creep, shatter, crack or splinter. It absorbs shocks, vibrations and movements in substructure, decreasing noise from traffic, is resilient at all temperatures, and not slippery when wet.

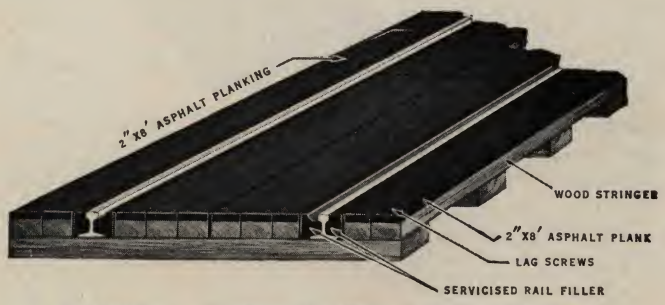
Servicised Rock Surfaced Planking comprises **Servicised** asphalt planking, having imbedded in its surface particles of rock. The imbedding of the rock in the surface of the planking aids in the prevention of skidding on a wet pavement. The same quality of material is in the base, as in the **Servicised** Standard asphalt plank.

Servicised Sementhread Planking comprises **Servicised** asphalt planking material having keys extruded in its surface and such keys filled with a mixture of concrete at the factory. This concrete is cured and allowed to set up at the plant and provides a surface, which is more skid-proof than other materials so far devised in asphalt planking. The advantages of this type of planking are that the ribs not only prevent skidding of the car in wet weather, but they act as reinforcing members in preserving a smooth, level appearance of the roadway. They also add stiffness to the structure, and make a better wearing surface than either the Standard asphalt plank or the imbedded Rock Surface.

All **Servicised** planking materials have been thoroughly and uniformly tested, and **Servicised** does not know of a planking job that has been replaced on any job that it has been recommended. In fact, we have no record of ever having replaced any planking although we do know that some of it has been used under conditions for which it was not recommended.

Servicised Highway Crossing

A combination of Fibrated Asphalt Planking and Servicised Premoulded Rail Filler laid as a smooth, non-skid pavement across railroad rights of way. The crossing is made water and weatherproof and safety



Installation of Protection Course on a Railroad Structure.

of road travel is increased because the hazards of travel are decreased whenever the smooth high road is extended across and over tracks. It is a real contribution to better, safer and more economical highway construction. The Highway official has an initial responsibility for building safety into crossings.

Send your specifications for estimates; they will prove the economy of this construction.

Servicised Waterproofing Protection Course

This material consists of preformed sheets, made up of specially blended asphalt combined with asphalt saturated felt and reinforced substantially with strong, tough, long fiber. The process by which these materials are combined, develops a tough, resilient, waterproof sheet, which, laid over the waterproofing fabric, maintains its integrity under the most





Close-up of Protection Course Being Laid on North Viaduct Approach to LaSalle St. Bridge, Chicago

severe conditions. On roofs, decks, viaducts, bridges and approaches; as a waterproof lining for walls, tunnels, swimming pools, etc., the toughness, elasticity and generally protective qualities of Servicised Waterproofing Course will act to prolong the life, lessen the maintenance and increase the service from the structures.

Servicised Industrial Flooring

This is a fiber-asphalt product formed under extreme pressure, consisting of a uniform mixture of high melting point asphalt, into which is incorporated asphalt-saturated, finely divided, first grade rag felt fiber, asbestos fiber, and a selected mineral filler. It is laid like any plank and makes long-life, silent, dry and resilient floors for factories and industrial use generally.



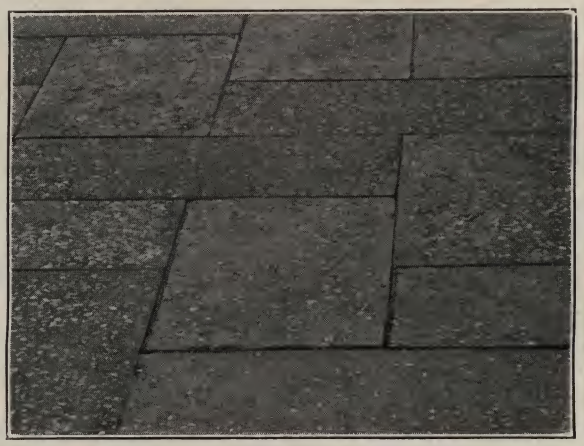
Section of Angle Edge Industrial Flooring

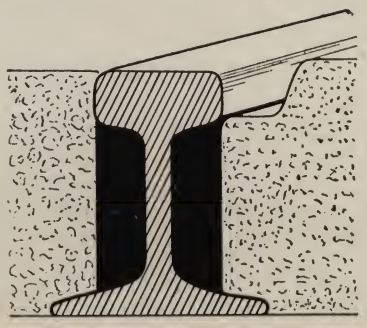
The flooring is made in several shapes—straight edge, over-lap, angle edge and "V" edge.

Thicknesses range from ½ to 2 in. by ¼ in. gradations. Standard widths range from 6 to 12 in. by inches. Standard lengths are 5 ft. Other dimensions will be supplied on order.

Servicised Rail Filler

The maintenance cost of a pavement adjacent to car rails can be reduced by a careful study of the cause of disintegration. When a rigid pavement is placed in contact with a steel rail, destruction of the pavement is inevitable. Water accumulates in the cracks and freezing causes non-alignment of the rails and breakage of the cement. Expansion and contraction will do likewise. Servicised fibrated bituminous rail filler has a base of high grade blown petroleum asphalt selected for its resiliency, weather- and temperature-resistance. This material is uniformly reinforced by long fiber saturated felt which adds to its strength and eliminates brittleness. The mixture of asphalt and felt forms a water-proofing matrix for the partially saturated cellular fiber giving Servicised rail filler its remarkable sound-deadening qualities. By correct proportioning and perfected processing Servicised Laboratories, Inc. have succeeded in producing a superior type of track insulation.

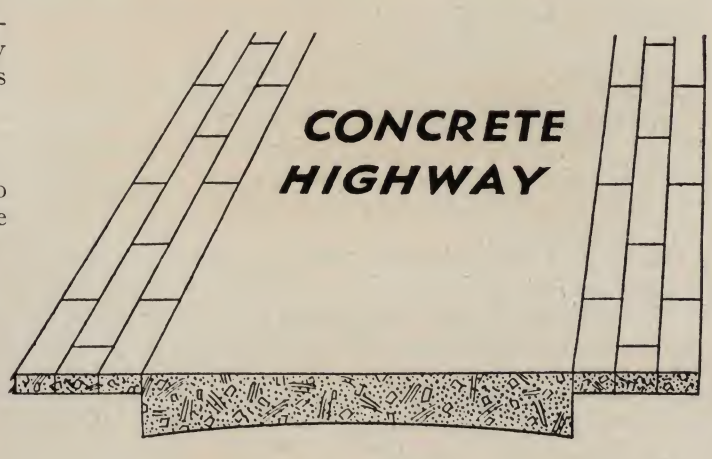




Inside and Outside Rail Filler Sections for Street Railway Rail

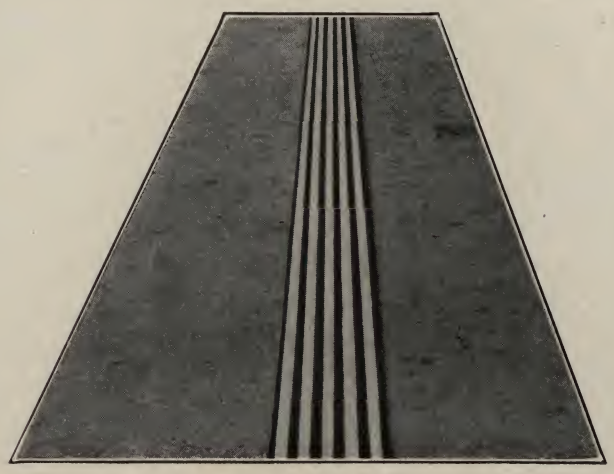
Asphalt Plank Shoulder

When Servicised Asphalt Planking is used for the highway shoulder, it eliminates the necessity of hardening surfaces immediately adjacent to the concrete slabs, greatly reduces the danger of breakage and splintering at the edges of the concrete, and assures a waterproof, resilient, perfectly fitting shoulder—permanent, economical, absorbing shocks and vibrations—one that will not corrugate or creep

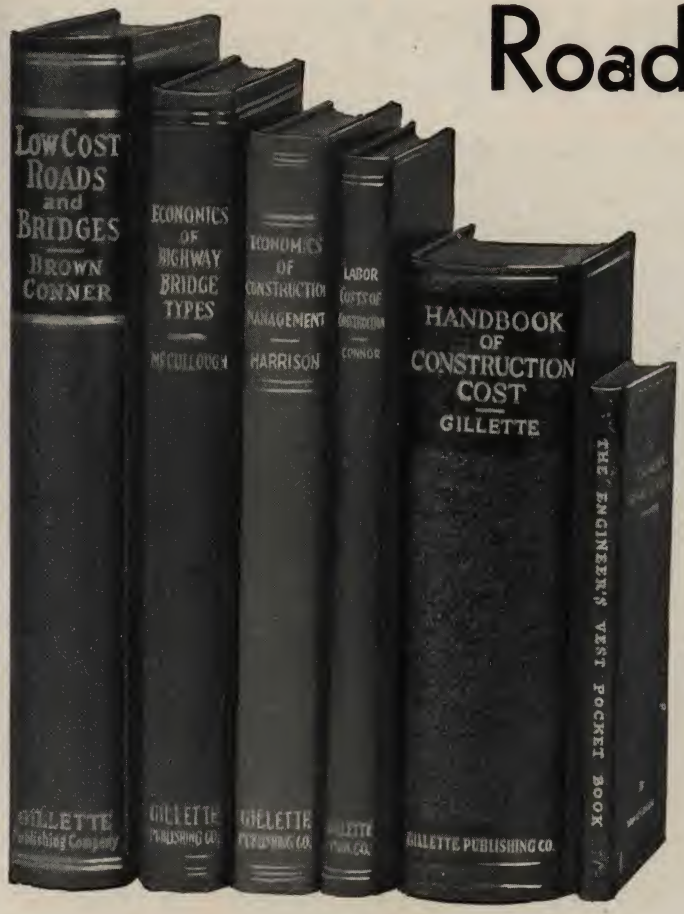


—and one that can be laid in "lightning-quick" time. The planks, fabricated in any length and in thicknesses of 1½" and 2" are shipped direct from the factory ready for bolting and laying.

Servicised Traffic Marker comprises **Sementread** planking placed longitudinally in the center of the road to act as a traffic marker on highways.



THE Road Builders' Library



The Road Builders' Library has been planned to give in a clear, concise form, the most up-to-date data available. In its six volumes you will find summarized the experience and practical knowledge of some of the most successful highway engineers. It is invaluable as a reference source for your NEW jobs. It tells how similar work was effectively and profitably handled elsewhere—pointing out what the limitations are and how results may best be obtained. It gives you useful calculations already worked out, tables, charts, and other useful data that provides a short-cut to *Profit-Making.*

Examine This Library at Our Expense

You cannot begin to judge the value of these books in your work until you have seen them, examined them, and put them to a practical test.

Read the chapter headings, examine the charts and tables, and study the examples. Then if you feel, as we do, that this library is a truly valuable set of reference works, you may keep it by making a few small monthly payments.

Glance through the brief summary of the contents of this timely library and then mail the coupon below and a complete set will be sent for ten days' free examination. Here is your opportunity to prepare yourself to figure profitably on the new jobs this spring.

Here Are the Contents in Brief:

Economics of Construction Management
By J. L. Harrison

Contents: Origin of Profit-Financing Construction Work—Securing Business—Planning Operations — Purchasing the Material Supply—Central Office Responsibility vs. Responsibility of the Job Management—Cost Accounts and Records—Production Cost and Expenses—Control of Expenses—Management of Production—Possibilities of Failure—Units—Labor as a Factor in Cost—Material—Operating Expenses — Depreciation—Equipment Replacement Problem—Financial Statements.

330 pages, 5¾"x8¼", blue cloth and gold, list price $3.75.

Low Cost Roads and Bridges
By Brown and Conner

Sections: I. Design of Local Highways. II. Economics and Planning. III. Location, Design and Grading. IV. Untreated Surfaces. V. Bituminous Surface Courses. VI. Use of Concrete for Low Cost Roads. VII. Materials and/or Proprietary Mixes. VIII. Interpretation of Tests. IX. Equipment and Machinery. X. Maintenance. XI. Low Cost Bridges and Culverts.

—— pages, —x—, fully illustrated, list price $6.00.

Engineers' Vest Pocket Book
By W. A. Thomas

A handy, compact source of reference for practically all engineering problems in the field or at the office. Replete with formulas, tables and diagrams helpful in providing short-cuts.

151 pages, 3"x5½", flexible, illustrated, list price $3.00.

Handbook of Construction Costs
By Halbert P. Gillette

Contents: Engineering Economics—Prices and Wages—Hauling—Excavation Economics—Concrete Construction Dams, Reservoirs and Standpipes—Water Works—Water Treatment Plants—Irrigation—Land Drainage—Sewers—Sewage Treatment—Garbage Disposal — Street Sprinkling, Cleaning and Snow Removal—Roads and Pavements—Highway Bridges and Culverts — Railway Bridges—Steam Railways — Small Tunnels — Large Tunnels—Bank and Shore Protection—Docks and Wharves — Building Construction—Engineering, Surveying and Overhead Costs—Miscellaneous Costs.

1,734 pages, flexibly bound, fully illustrated, list price $6.00.

Economics of Highway Bridge Types
By C. B. McCullough

Contents: General Factors Controlling Type Selection—Fundamentals of Economics Analysis—Bridge Types—General Discussion and First Cost Data — Short Space Superstructures — Longer Space Superstructures — Substructure Types—Miscellaneous Types and Cost Data—Renewal and Maintenance Costs—Unit Costs—Illustrative Problems in Type Selection.

246 pages, cloth bound, fully illustrated, list price $5.00.

Labor Costs of Construction
By Frank L. Connor

Earth Excavation and Transportation—Rock Excavation—Sheet Piling and Cofferdams—Wood and Concrete Piles—Concrete Costs—Concrete Form Costs—Steel Reinforcing — Structural Steel—Timber Work—Rough and Finished Carpenter Work — Brick and Tile—Masonry — Plastering and Plumbing—Painting—Sewers — Water Works—Concrete and Other Paving Costs—Equipment and General Labor Expense.

$26.75 Library for $21.00

TEN DAYS' FREE EXAMINATION

USE ORDER CARD NO. 8
on Page 137 when ordering this Library.

GILLETTE PUBLISHING CO.
400 W. Madison St. Chicago, Ill.

THE T. L. SMITH COMPANY

2841 North 32nd St., Milwaukee, Wis.

Manufacturers of Concrete Mixers and Pavers

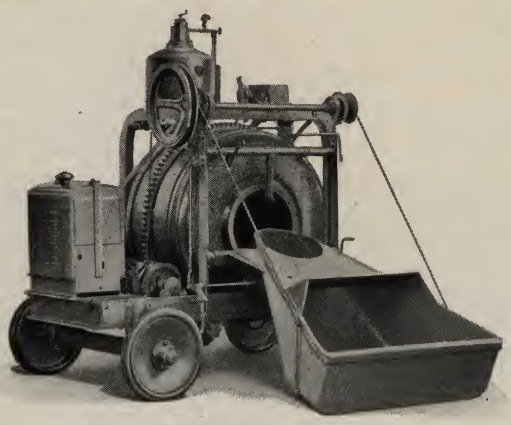
Sales Offices and Service Stations in all Principal Cities.

PRODUCTS: Concrete Paving Mixers, Tilting and Non-Tilting Mixers.

History: Established in 1900, this company has been a big factor in advancing the use of concrete. Smith mixer and paver developments are therefore the result of a long period of actual experience.

Smith Mixers: The first commercially successful machines developed for the mechanical mixing of concrete. Many refinements have been added from time to time to insure better mixed concrete, longer life of the machine, and low maintenance costs.

There is a Smith mixer for every kind of concrete job—for sidewalks, gutters, alleys, foundations, culverts, bridges, retaining walls, dams, buildings, roads, etc. The capacities range from the small Mascot 2½-S to the big Smith 112-S four yard tilter —the largest mixer in the world.



Smith 10-S Non-Tilter for highway, bridge and culvert construction.

Smith Pavers: 27 cubic foot capacity. Built for high-speed, big production, continuous operation at lowest maintenance cost. Produces uniform high-strength concrete at lowest cost per yard. Husky, solid-riveted, heavily braced, single-unit frame with low overall height. No bolted on super-structure. Lowering device standard. Compact—simple in design—full automatic operation —control levers grouped in 27″ circle.

Paver Drum: Big diameter drum—ten full-width non-clogging buckets—dished drum heads—central drum ring cast integral with machined roller track. Famous end-to-center mixing action provides "Smith Specification Concrete—uniform to the last drop."

Fewer Parts—Fewer Repairs: Hoist, mixing drum and bucket drives are all on one shaft, assuring perfect alignment and easy accessibility. High carbon cut steel gears and anti-friction bearings throughout—fast operating gears, heat-treated. Simple outside band type clutches throughout, easily adjusted. Clutch bands on boom and bucket traction drums interchangeable.

Water Tank: New Smith central pipe water tank accurate to the ounce and unaffected by slope. Indicator dial below tank. Platform control. Water controlled through a three-way non-by-pass valve. Auxiliary water tank standard.

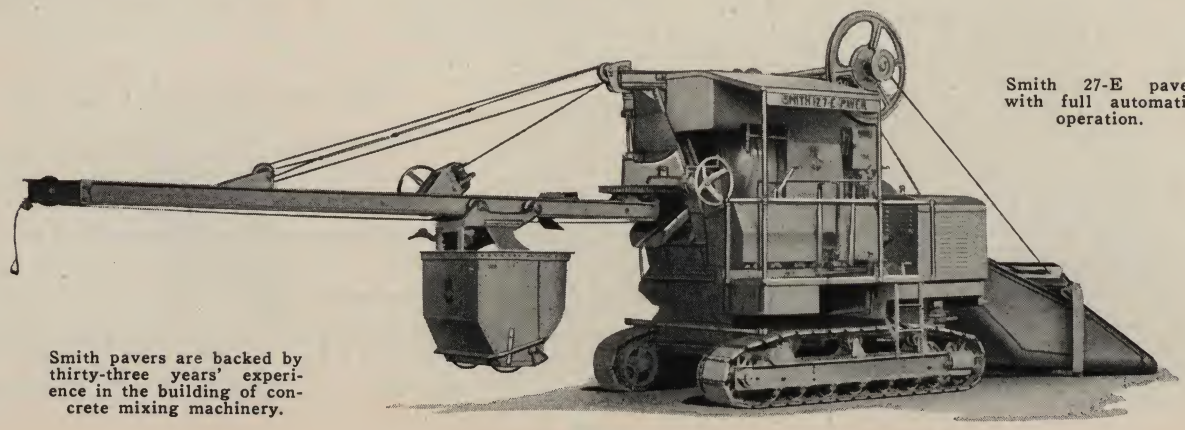
Fast Charge and Discharge: Big streamline skip, with cable compensator. No bottle necks. Skip, 96″ wide, large enough to accommodate dual-tired truck. Discharge chute extends two-thirds through drum and swings out completely during mix period.

Traction: Full-length traction—simple design—foot treadles on operator's platform permit either side cut out for steering purposes.

Boom and Bucket: Speedy placing of concrete—standard 25 ft. boom—bucket dumps batch at any point of travel. Automatic take-up on bucket control cables—no adjustment necessary. Boom can be swung by power or hand from operator's platform —or by men on the subgrade.

Capacity: Complies with A. G. C. requirements for 27-E paver.

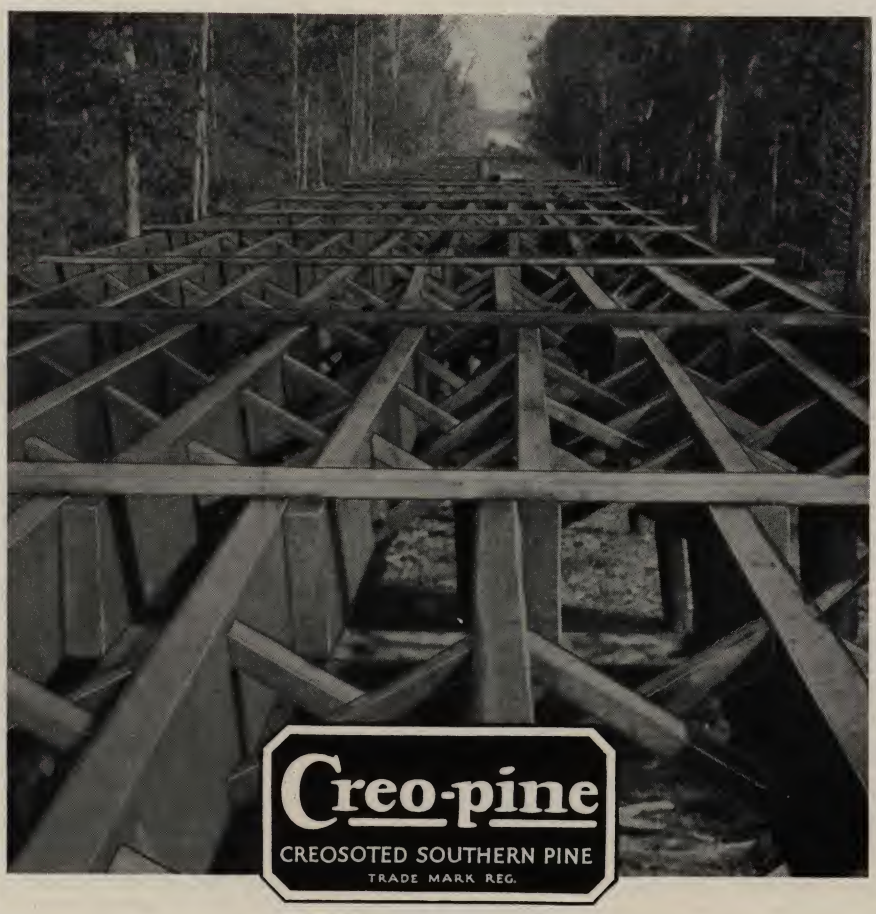
Catalog: Complete specifications and details of construction given in our new catalog, a copy of which will be mailed on request.



Smith 27-E paver with full automatic operation.

Smith pavers are backed by thirty-three years' experience in the building of concrete mixing machinery.

SPECIFY CREO-PINE PILING



Creo-Pine Piling is carefully selected in the forests, and rigidly inspected from standing tree to finished product. It is creosoted its entire length by the Standard Pressure Vacuum Process. The creosote oil used is manufactured by the largest distillers in the United States from pure coal tar, and is produced to meet the rigid requirements specified by the engineering associations of this country.

Southern Wood Preserving Company plants are located in timber producing territories with quick access to the producing forests, insuring prompt shipment to treating plants for creosoting and prompt delivery to you.

Creo-Pine Bridge Timbers and Piling resist the ravages of decay and attacks of the marine borers. The life of creosoted piling and timbers is not known. There are numerous cases on record showing that creosoted piling and timbers have been in use from 20 to 45 years and are still pronounced sound by engineers.

Skillful manufacture, precision during treating processes, supervision by men who have had over 26 years of wood preserving experience, is why Creo-Pine Piling will give you maximum years of service, lower maintenance costs, fewer replacements and repairs at minimum costs per year.

SPECIFICATIONS

TREATMENT: As service conditions vary so much, it is impossible to recommend a particular treatment for these materials without first knowing the purpose for which they are to be used.

Inquiry regarding your requirements to any of the plants or offices listed below will bring prompt information, and if desired, experienced Creo-Pine engineers to your office for personal consultation. This service is yours without obligation.

SOUTHERN WOOD PRESERVING CO.
ATLANTA, GA.

Sales Offices:
NEW YORK
10 East 43rd St.
BUFFALO
Genesee Bldg.
PHILADELPHIA
Girard Trust Bldg.
TOLEDO

Treating Plants:
EAST POINT, GA.
CHATTANOOGA, TENN.

Sales Offices:
PITTSBURGH
Dollar Savings & Trust Bldg.
DETROIT
Buhl Bldg.
CHARLOTTE
CHATTANOOGA

STANDARD OIL

(INDIANA)

910 SOUTH MICHIGAN AVE.

Producers and Makers of Asphalt for every

Following are the most important of present-day advances in Road Maintenance and Construction.

Road Oil of consistencies to prevent matting when proper method of application is used and where the oil is used on the road for the purpose of semi-binding the mineral aggregate used on what is known as sandy, loamy gravel roads. Oil thus used prevents the road material from blowing away, and proper dragging of the road keeps it in smooth, easy-riding condition and waterproofs it to a great extent.

Road Oil of consistencies for the purpose of developing a wearing surface on roads, where there is enough mineral matter or base, with the correct application and correct grade of road oil and sufficient mineral matter, develops a surface treatment or what might have once been called a "mat coat." This is no longer called a "mat coat," as it is a bituminous surface treatment, which, when properly applied, penetrates and adheres firmly to the road.

Road Oil of consistencies for use on ordinary earth, dirt, clay or gumbo roads. These road oils should be selected to suit the road to be oiled, with a view of developing as much waterproofing qualities as possible, and preventing the blowing away of the road in the form of dust.

Road Oil of consistencies for construction and the building up of roads by the Mixed On the Road Method, using available aggregates such as gravel, stone with road oil. This is an economical way of building low cost improved farm to market and secondary roads.

Cut Back Asphalts developed from high grade asphalt bases by the use of a solvent or diluent. After the diluent is evaporated by exposure to the air the asphalt base remains exactly as it was before mixture with the diluent. Cut Back Asphalts are high grade bituminous cements or bituminous binders, which firmly cement mineral aggregate in place, forming durable wearing surface. Stanolind Cut Back Asphalts are developed in different grades and consistencies for different kinds of work, including:

Cut Back Asphalt for Surface Treatment in one, two and three applications, building up a wearing surface of from ⅜-inch to ¾-inch thickness.

Cut Back Asphalt for Retread, otherwise known as mixed-in-place, by the use of bladers and drags. By this method a two-inch bituminous wearing surface can be formed that is exceptionally strong, gives long life, and is smooth, easy riding. Such a surface when properly developed upon a sufficient foundation will carry as heavy loads as any other type of pavement.

Cut Back Asphalt for Cold Mix for making mixtures and coating stone in the ordinary concrete-mixing machinery. It can be applied by the same methods and with the same equipment as any type of concrete mixture regardless of the kind of cement used, whether it be hydraulic or bituminous.

It should be constructed in courses not to exceed three inches in thickness.

Cut Back Asphalt for Asphalt Macadam Pavement, penetration method. This type pavement, with the use of Stanolind Cut Back Asphalt, has proved to be highly successful and valuable, especially so where it is impossible to secure crushed stone or gravel that is free from dust. The diluent used



LIQUID ASPHALT—"road oil" has been developed into an effective bonding material, manufactured to rigid specifications by the Standard Oil Company (Indiana). It is made in four grades—to fit all seasonal conditions, types of aggregate, and methods of mixing—and is now being used on approximately 8,000 miles of road each year.

COMPANY

CHICAGO

purpose...Stanolind Brand

to cut back Stanolind Paving Asphalt develops a bituminous cement of such low viscosity that it will penetrate into the dust and effect a thin film of bituminous coating on the mineral aggregate. It is recommended in place of a hot asphalt method where the conditions are not ideal for the use of solid asphalts that require raising to a temperature of approximately three hundred and fifty degrees Fahrenheit to make them workable. The penetration method overcomes the hazard encountered with the chilling of hot asphalt when it comes in contact with cold-crushed stone or gravel.



Lake Shore Drive, Chicago, Ill.

Cut Back Asphalt for Repair Work, either machine or hand-mixed. With the use of Stanolind Cut Back Asphalts, especially developed for this work, cold mixes or cold-patch work can be made at almost any time of the year, and Cut Back Asphalt surface treatment on old sheet asphalt or asphaltic concrete pavements, or any bituminous pavements that show signs of wear, cracking and weathering, make these pavements as good as new.

Asphalt for Hot Surface Application, developed with an especially low viscosity at working temperature. This asphalt has exceptional penetrating qualities because of its fluidity permitting it to penetrate into interstices and cracks to a much greater extent than asphalts of higher viscosity and less fluidity at practical working temperature. These asphalts have been made to meet the requirements for surface treating of all kinds of roads and pavements.

For five years, a half-inch surface of Stanolind Cut Back Asphalt has been handling the traffic of the world's busiest thoroughfare—Michigan Boulevard and Lake Shore Drive, Chicago.

Stanolind Asphalts of the proper consistencies and cementing values for building asphalt macadam pavements, penetration method, hot application.

• • •

Paving Asphalts for Hot Mix Sheet Asphalt, Hot Mix Asphaltic Concrete and all types of pavement in which bituminous or asphaltic cements are used, such as Paving Fillers for brick, granite block and other block pavements; Crack Fillers; Expansion Joint Fillers; Water-proofing Asphalts for the surfacing of hydraulic cement pavements, retaining walls, bridges and abutments.

Also Stanolind Asphalts for use in manufacturing and producing many different things entering into almost every manufactured article on the market.

We shall be glad to send you any information that we can give, and to furnish you specifications and recommendations on all types of Road Construction and Maintenance in which Asphalt and Road Oil are used.

A typical example of sheet asphalt paving (Grand Rapids, Michigan), using Standard Asphalt Cement, is illustrated at the right. This type can be laid over rough, uneven pavement for a foundation, where the existing streets have sufficient strength for traffic requirements.



Copyright 1934 Standard Oil Co.

STANDARD OIL CO. OF NEW YORK, INC.

A SOCONY-VACUUM COMPANY

26 BROADWAY, NEW YORK, N. Y.

PRODUCTS—Asphalt, Asphalt Binders, Asphalt Cements, Waterproofing Asphalt, Liquid Asphalt, Cold Patch Asphalt, Paving Fillers, Cut Back Asphalt for Surface Treatment and Mixed in Place Construction, Asphalt Emulsion.

Standard Paving Asphalt

(Socony Brand)

For Sheet Asphalt Paving, Asphaltic Concrete and Hot Mix Pavements.

It is refined to the required penetration within reasonable range. Contains not less than 99½ per cent of pure bitumen, which does not precipitate under any conditions.

It not only possesses sufficient ductility and cementing value to meet the widest range of conditions, but it is so rich that a maximum amount of yardage per ton of Asphalt is obtained.

Standard Asphalt Binders "A", "B" and "C"

(Socony Brand)

An Asphalt having a fixed degree of hardness will not meet all requirements. We have therefore developed three Asphalt Binders of different degrees of hardness.

Binder "A" for surface treatment of Macadam Roads.

Binder "B" for building Bituminous Macadam Roads by the penetration method.

Binder "C" for use, like Binder "B," for penetration where a harder binder is required.

Standard Liquid Asphalt

(Socony Brand)

For the proper treatment of various types of roads and conditions of road surfaces, we have produced several grades of Liquid Asphalts and Cut Back Asphalts ranging from light dust-laying oils to the heavier types for blanket treatment, honing, and mixed in place methods.



State of Vermont road near North Bennington, Vt., built with Socony Asphalt Cut Back, mixed-in-place method.

Standard Cut Back Asphalt

(Socony Brand)

ROAD MIX OR MIXED IN PLACE CONSTRUCTION

"Road Mix" or "Mixed in Place" Construction with Standard Cut Back Asphalt as the binding medium is rapidly finding an important place in road building. There are two types of road mixes which are being successfully used in producing low cost, wearing courses.

The first is so-called Gravel Mix, consisting of a graded gravel, ranging from about 1" in diameter down to and including dust. This type is for reconditioning an existing wearing course, such as gravel, which has become disintegrated.

The other, or Macadam Aggregate, type of mixture is constructed with crushed stone running from ¾" to 1¼" in size. This type provides an entirely new wearing course on a well bonded base.

Each of these types requires a different grade of Standard Cut Back Asphalt for binding the mixture. The application is made with our modern distributors, and the mixing takes place immediately thereafter, using mixing or blading machines. Through these methods a wearing course 2" to 2½" compacted thickness is secured, providing a well bonded and durable surface.

Standard Asphalt Paving Fillers

(Socony Brand)

For filling the joints of brick, block and concrete pavements. A specially refined Asphalt of high melting point, or a Mineral filled Asphalt, both of which may be either poured or squeegeed into the joints, producing a rigid, noiseless and easily repaired pavement.

Standard Asphalt Emulsion

(Socony Brand)

For use in surface treatments, penetration type construction, road and plant mixed pavements, patching.

Standard Cold Patch Asphalt

(Socony Brand)

For repairing holes, ruts, and depressions in all types of bituminous road surfaces.

For restoring worn, uneven surfaces of brick, granite block, and wood block pavements.

This material is made to be used at all seasons of the year without heating.

METHOD OF MIXING

For each cubic yard of ½" to ¾" dry stone, use about 16 gallons of Standard Cold Patch Asphalt. It can be mixed with shovels on a mixing board, in a wheelbarrow, or with a suitable mechanical mixer.

The quantity of Cold Patch Asphalt may be increased or diminished conforming to the size of the mineral aggregate used, but avoid a too rich or too lean mixture.

Shipments

All products will be shipped in tank cars, drums or wood barrels. Tank truckload deliveries to job, or applied on work and shipment in insulated tank cars by special arrangement.



Gouverneur-Oxbow, St. Lawrence County, New York State. Constructed with Standard Macadam Asphalt Binder "B."

The Methods and Costs Library—

the accumulated experience of many engineers, contractors and builders throughout the nation.



These 5 Books for Constant Reference

Volume I
Gillette's Handbook of Construction Cost
1,734 Pages, 4½x7. Illustrated
Price $6

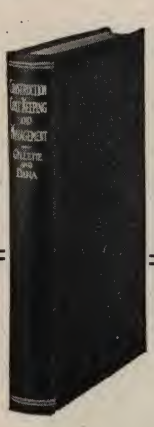
Volume II
Dana's
Handbook of Construction Equipment
New Second Edition
349 Pages, 4½x7. Illustrated
Price $6

Volume III
Gillette & Dana's
Handbook of Mechanical and Electrical Cost Data
Over 1,500 Pages, 4¾x7. Illustrated
Price $6

Volume IV
Gillette's Handbook of Cost Data
1,854 Pages, 4½x7. Illustrated
Price $6

Volume V
Connor's Labor Costs of Construction
200 Pages, 5x3¾
Price $2

Gillette's "Construction Cost Keeping and Management" standard treatise on organizing business for economy and profit; 572 pages. Without charge when you decide to keep the library.



This Book FREE

The Value of this library can be fully realized in only one way—at your elbow, accessible for reference as job succeeds job in your own experience. We know this from the reports of contractors and engineers who date the growth of their business prosperity from their first reference to these volumes.

Thus, we do not ask you to buy them first and learn their value afterward. We offer to put them at your elbow free of charge for a trial. Use them. Get the flavor of their helpful counsel. Check your own habits in figuring costs or selecting methods, in comparison with the general standard practice among builders everywhere.

After you skim through the broad subject headings at the right, send the coupon.

This List of Subjects Covered

Engineering Economics — Prices and Wages—Hauling—Excavation Economics — Standpipes —Concrete Construction — Dams—Reservoirs, and Water Works—Water Treatment Plants — Irrigation — Land Drainage—Sewers — Garbage Disposal — Roads and Pavements — Bridges and Culverts—Steam Railways and Tunnels — Docks and Wharves—Electric Motors—Lights —Miscellaneous Costs—Earth Excavation and Transportation—Rock Excavation—Steel Piling and Cofferdams—Wood and Concrete Piles —Concrete Costs—Concrete Form Costs—Steel Reinforcing — Structural Steel—Timber Work—Rough and Finish Carpenter Work—Brick and Tile — Masonry — Plastering and Plumbing — Painting—Sewers —Water Works — Concrete and Other Paving Costs — Equipment and General Labor Expense.

Gillette Publishing Company
Technical Publishers
400 W. Madison St.
Chicago, Illinois

Ten Days' Free Examination

USE ORDER CARD NO. 7
on Page 137 when ordering this Library.

$32.00 Library
with this coupon
$26.90

SULLIVAN MACHINERY COMPANY

827 Wrigley Bldg., Chicago, Ill.

Portable Air Compressors

Sullivan Portable Air Compressors give fine performance under the most grilling conditions—they work hours, days and weeks on end without a stop except for oiling. Minimum cost for repairs or for delays due to breakdown—a point especially important when distant from the source of supplies. Sullivan Portables are built with steel wheel trailer, rubber tired spring trailer, truck or skid mounting. Distillate or diesel engine or electric motor drive.

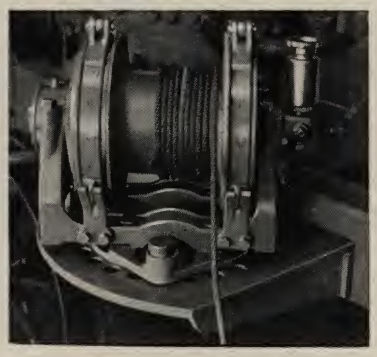


Portable Turbinair Hoists

Portable hoists operated by compressed air are useful adjuncts in road building equipment. Sullivan Turbinair hoists are built in 175 lb. and 345 lb. sizes—scarcely larger than a tool box—small enough to be carried about yet with a capacity of 1000 to 2000 lb. lift. All working parts are inside the drum for safety and compactness. Turntable mounting is supplied for attachment to portable compressor outfit as illustrated.

Rock Drills

Concrete breakers or "Busters" use any of the ordinary forms of tools made upon hexagon steel, with plain hexagonal collar shank. Handle quickly and at low cost pavement cutting, excavating hard pan, shale or frozen ground in trenches, back-fill tamping in trenches or shallow rock drilling. By substitution of front end parts, Sullivan concrete breakers can be converted into convenient and effective sheeting hammers.



Hand held hammer drills for trenching, block holing and general rock removal. Class "L-2" (illustrated) weighs 45 lbs. Has the power of a much heavier machine. Solid and hollow piston, air tube and water tube types. Sturdy and fast drilling in hard or soft rock.



Clay Spaders

Sullivan Spaders or clay digging tools take the place of a hand pick as well as the hand spade or shovel for excavating stiff clay where ground is not sufficiently hard to be drilled and shot.

Drill Sharpeners and Furnaces

Sullivan Drill Sharpeners employ an "all hammer" method which sharpens the steel gradually at a moderate heat. This avoids "burning" of the steel with consequent crumbling or chipping of corners and avoids wings or fins forming on the edges. The "all hammer" process makes the steel tougher with every sharpening. The Class "E" Sharpener is a portable outfit.

Sullivan Oil Furnaces insure gradual heating at safe temperatures.



Complete Equipment for the Road Contractor

Drill Steel
"Blue Dragon" Air Hose
Hose connections
Detachable Bits
Detachable Bit Grinders
Stringalite Lighting Cable
Anti-freeze "Tanner Tanks"
"Start-O" Heaters
Concrete Surfacers
Tools for Clay Spaders and Concrete Breakers

THE TEXAS COMPANY

Asphalt Sales Department

General Office: 135 East 42nd Street

NEW YORK

SALES OFFICES

New York, Philadelphia, Richmond, Buffalo, Chicago, Cleveland, Kansas City, Jacksonville, Houston, Dallas, Boston

ASPHALT REFINERIES

Port Neches, Tex. Marcus Hook, Pa.

Norfolk, Va. Providence, R. I. Lockport, Ill.

PRODUCTS: Asphalt Cements, Cut-back Asphalts, Emulsified Asphalts, Asphalt Surface-treatment Materials, Cold Patch

Heavy-Duty Paving Which Has Demonstrated Its Low Upkeep

On main highways, business thoroughfares, or wherever else traffic is very heavy, long service with attractively low maintenance is assured by Texaco Sheet Asphalt or Texaco Asphaltic Concrete Pavements. The Texaco Asphalt Cement, which acts as the binding medium in these pavements is virtually pure bitumen. Because of the scientific methods used in refining the asphalt, a pavement is secured which is efficient under all climatic conditions.

The resilient quality of these Texaco pavements permits them to absorb the impact of traffic, adding years to their service and lowering maintenance. The foundation for pavements of this type may be newly constructed. Frequently, however, an old, worn pavement of another type offers a substantial base for either of these Texaco surfaces.



Part of a New York State Highway Project, 26 miles long, in which Texaco Paving Cement was used.

Booklets describing the ingredients and steps in constructing heavy-duty Texaco Sheet Asphalt and Texaco Asphaltic Concrete paving will be furnished on request.

Almost No Maintenance in 22 Years



This Texaco Asphalt Pavement on Melon Bridge, Topeka, Kansas, which has been in service for the past 22 years, has required practically no maintenance.

Low-Cost Surfaces for Secondary Roads and Streets

A large part of every road and street system does not warrant the construction of expensive, high-type paving. For such streets and roads, Texaco Cut-back Asphalts and Texaco Emulsified Asphalts provide low-cost surfaces which will serve a moderate volume of traffic satisfactorily for a number of years.

In order to adapt these low-cost Texaco surfaces to conditions and local materials in all parts of the country, The Texas Company has perfected a variety of grades of Cut-back Asphalts and Emulsified Asphalts.



Pressure Distributor applying Texaco Cutback Asphalt in constructing a low cost road by the road-mix method.



A Blade Grader mixing the Texaco Cutback Asphalt and stone in the construction of the same low-cost road.

After a study of local conditions, a Texaco engineer will furnish complete information on the most suitable type of low-cost Texaco surface for your particular community. This service is, of course, offered without obligation.

Low-cost Texaco surfaces give excellent service under light to moderately heavy traffic.

Protective Surface Treatments for Streets and Highways

To improve the service and lower the maintenance cost of untreated gravel, macadam, shell, earth and similar road and street surfaces, use Texaco Surfacing Materials. Application of the proper quantity of the correct Texaco Surfacing Material, followed by a covering of sand, stone chips, slag, etc., forms a tough, water-shedding carpet on the old road.

Besides eliminating dust and mud, such a Texaco treatment is sound economy; it reduces maintenance costs and prevents the material on the old road or street from being ground up and blown away.

The Texaco Asphaltic products in this group are liquid in character. They vary in the percentage of pure asphalt cement contained in each, and include materials exactly suitable for treating all types of surfaces. A booklet devoted exclusively to this group of Texaco products may be had for the asking.

For the purpose of acting as a dust layer on roads and streets for the summer months, Texaco products include light asphaltic oils, easily applied and of proved effectiveness for this type of service.

In addition to doing away with the danger and nuisance caused by flying dust, these Texaco products also conserve the road material.

Cold Patching

An easy, convenient way of securing durable patches for all types of road and street surfaces is available through the use of Texaco Cold Patch. Without the necessity of heating, Texaco Cold Patch can be mixed with sand or stone chips, by hand or in a small concrete mixer. The resulting batch can be stored at some central point and trucked out from time to time to the road or street to be patched.

A special booklet on the proper method of preparing and using Texaco Cold Patch will be sent on request.



This smooth, easy riding street in Miami Beach, Fla., is the result of the use of a Texaco Asphalt Surfacing Material.

For thirty years, Texaco Asphalt products have helped construct and maintain the country's streets and highways. Every State east of the Rocky Mountains has used these products. Streets and highways improved with Texaco Asphalt also serve Europe, Asia, Africa, South America and Australia.

You will find the recommendations of a Texaco engineer a real help in solving your road and street problems. Why not send for him?

THE TIMKEN ROLLER BEARING COMPANY

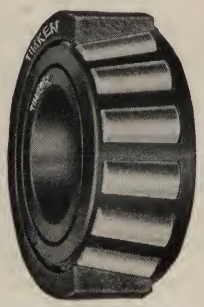
Manufacturers of Tapered Roller Bearings

CANTON, OHIO

BRANCH ENGINEERING AND SALES OFFICES IN PRINCIPAL CITIES

Design

The Timken Tapered Roller Bearing consists of three load-carrying elements, the tapered or conical rollers operating between the inner race or tapered cone, and the outer race or tapered cup. True rolling action is assured by making the apexes of the conical surfaces of the cone, cup and roller coincide on the axis of the bearing.



Standard Timken Bearing

The rollers contact against the back rib of the cone in two well-separated areas. For this reason they are positively aligned at all times without guidance by the cage, which merely serves to space the rollers about the cone. This feature, exclusive to Timken Bearings, increases the capacity for all types of loads while greatly reducing friction.

These parts are made of Timken steel, hardened and ground accurately to size. A one-piece pressed steel cage to retain the rolls about the cone completes the bearing.

Advantages of Timken Bearings

Thrust Load—Because of their tapered construction, Timken Bearings meet every possible combination of both radial and thrust load and do so much more efficiently, thoroughly and completely.

Power Saving—On account of the true rolling motion of Timken Bearings, friction, whether resulting from radial load or thrust load, is eliminated. Actual results in every day service show that there is a substantial saving of power resulting directly from Timken installations.

Saving Lubricant—Timken Bearing applications may be enclosed in such a way that there is ample space in the housing for a liberal supply of lubricant. Usually it is not necessary to renew this excepting at very infrequent intervals which results not only in an actual saving of lubricant, but the time required to inspect the application and replenish the supply.

Elimination of Shaft Wear—All moving contact in Timken Bearings is between the hardened and ground surfaces of the bearings themselves. For this reason there is no motion and consequently no wear either in the hub or on the shaft. For this reason, the initial precision is retained indefinitely.



Timken Rock Bit

The Timken Rock Bit is making radical savings in drilling costs in all parts of the country. Write for complete information about it.

Engineering Service

Complete technical data is available in the Timken Engineering Journal which covers dimensions, load rating and capacity tables, speed capacity curves, simplified methods of calculating bearing loads, information on closures, fitting practices, assembly and lubrication.



Timken Thrust Bearing

Additional technical information is available showing specific applications of Timken Bearings in

Back Fillers	Loaders
Bull Dozers	Motor Graders
Clam Shell Buckets	Motor Trucks
Clam Shell Scrapers	Mud Pumps
Compressors	Pavers
Concrete Conveyor Tanks	Paving Plants
Concrete Mixers	Planers
Concrete Surfacers	Power Shovels
Contractor Wagons	Pumps
Conveyors	Road Rollers
Diesel Engines	Rock Crushers
Ditch Diggers	Roller Screens
Drag Line Hoists	Rooters
Dredges	Sand Driers
Earth Removers	Sand Washers
Excavators	Sanders
Elevating Graders	Scarifiers
Form Graders	Spreaders
Gas Engines	Tractors
Gravel Washers	Trailer Scrapers
Hoisting Towers	Truck Mixers
	Vibrating Screens

All the above data is available to manufacturers and engineers and will be supplied gladly.

The experience of the Timken Engineering Department is also available on all problems.

This service is confidential and without charge or obligation and is being used continually by leading manufacturers in all industries.

THE TOLEDO PRESSED STEEL CO.

Toledo, Ohio

Toledo Torches

"The harder it blows, the better they burn."



Leader



Model "F"

The ideal safety light. Used by 44 out of the 48 state highway commissions. The best torch value because it is the **only** torch equipped with the fuel-saving Economy Burner.

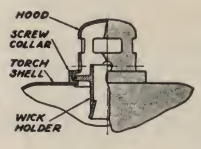
"Leader" rights itself from any position; uses kerosene; capacity, three quarts; equipped with the famous Economy Burner. Burns up to 48 hours on one filling; made from 20 gauge steel; halves joined together with a leak-proof double seamed joint; finished in high luster black, baked enamel finish; weight, 5½ pounds; packed ¼ dozen per box.

"Champion" self righting; same size and capacity as "Leader," but made of 14 gauge steel and welded at the seam. Weight 6¾ pounds; packed ¼ dozen per box.

Model "F" not self-righting. Burns 24 hours on one filling. Made of 20 gauge steel; halves joined together with leak-proof double seamed joint; weight 2½ pounds; packed ⅓ dozen per box.

Nameplates

Nameplates with wording limited to four lines, may be welded to any of the above torches, at the factory. Each.....$0.15
Per dozen 1.25
Single orders of 6 dozen or more, no charge.



The Economy Burner. Detail of Economy Burner now used on all Toledo Torches. This burner may be attached to torches using other types of burners. See detailed parts information below.

Economy Burner complete, each.....$0.50



Burner Hood



Burner Adapter



Burner Wick Holder

Economy Burner hood only. Each.....$0.15
Economy Burner wick-holder only. Each..... .15
Economy Burner adapter only. Each..... .25
All complete Economy Burners furnished with copper gasket and full length wick, ready for use.

EXTRA WICKS

Standard round braided cotton

Per dozen .....$ 1.50
Per gross 16.00

Packed in boxes of one dozen only.
Carriage prepaid on all parts shipments.

Toledo Folding Steel Horses







Widely used for barricades, scaffolds, benches and miscellaneous supports. They are quickly set up—as easily as walking up stairs. No springs, no bolts, no clamps, no loose parts of any kind. Fit standard sized lumber. They grip tightly, making a horse of absolutely rigidity — no sway. Support enormous weight. Quickly taken down, fold compactly, store snugly. A pair will outlast a dozen wooden horses, therefore much more economical. Handling and storage costs greatly reduced. Legs of heavy gauge steel in 3″ ribbed channel section. All pivoted joints securely fastened. Finished in baked enamel, packed one pair in a box.

For lumber of nominal thickness of 2″			For lumber of nominal thickness of 1″		
Size No.	Approx. Height, Inches	Approx. Shpg. Weight, Lbs. per Pair	Size No.	Approx. Height, Inches	Approx. Shpg. Weight, Lbs. per Pair
18	18	18	181	18	18
25	25	24	251	25	24
32	32	27	321	32	27
36	36	30	361	36	30
42	42	36	421	42	36
48	48	41			
54	54	46			
60	60	60			
For lumber of nominal width* of 8″					
258	25	27			
328	32	30			
368	36	36			

**The jaws fit the ACTUAL width of a standard 2x8, namely 7½″*



ONE PAIR



TONCAN CULVERT MANUFACTURERS' ASSOCIATION

YOUNGSTOWN, OHIO

MEMBER MANUFACTURERS

BEALL PIPE & TANK CORP., Portland, Oregon; Seattle, Washington; Spokane, Washington; Boise, Idaho.
BERGER METAL CULVERT CO. OF N. E., Boston, Mass.
BLUE-GRASS PIPE & CULVERT CO., Louisville, Kentucky.
CANTON CULVERT CO., Canton, Ohio, and Danville, Illinois.
CHOCTAW CULVERT & MACHINERY CO., Memphis, Tennessee.
FIRMAN L. CARSWELL MFG. CO., Kansas City, Kansas; Dodge City, Kansas; Grand Island, Nebraska.
DOMINION METAL & CULVERT CORP., Roanoke, Virginia.
EASTERN CULVERT CORP., Philadelphia, Pennsylvania.
A. N. EATON METAL PRODUCTS CO. OF MONTANA, Billings, Montana.
A. N. EATON METAL PRODUCTS, Omaha, Nebraska.
EMPIRE STATE CULVERT CORP., Groton, New York.
JENSEN BRIDGE & SUPPLY CO., Sandusky, Michigan.
H. V. JOHNSTON CULVERT CO., Minneapolis, Minnesota.
WM. E. NEWMAN & SONS CO., Ogden, Utah.
PEDLAR PEOPLE, LTD., Oshawa, Ontario, Canada.
THOMPSON MFG. COMPANY, Denver, Colorado.
TRI-STATE CULVERT MFG. CO., Memphis, Tennessee; Atlanta, Georgia.
WESTERN PIPE & STEEL CO. OF CALIFORNIA, Los Angeles, California; San Francisco, California.
WYATT METAL & BOILER WORKS, Dallas, Texas; Houston, Texas.

Write your nearest manufacturer for information and prices.

PRODUCTS: Toncan Iron Corrugated Culverts, Sectional Plate Pipe, Tyton Highway Guard, Tyton Gates.

REG.U.S.PAT.OFF.
TONCAN
COPPER
MO·LYB·DEN·UM
IRON CULVERTS

Made by the world's largest producer of alloy irons and steels, Toncan Iron represents the highest type of culvert material available. It is an alloy of scientifically refined iron, copper and molybdenum possessing rust-and-corrosion-resisting qualities far in excess of those possessed by any other commercial iron or steel suitable for culverts—a fact proved by more than 10,000 tests in actual service.

ADVANTAGES OF TONCAN IRON CULVERTS

Toncan Iron Culverts, due to their resistance to rust and corrosion are long-lasting, the extra years of service far overshadowing their slightly higher first cost. They are easy to install. Only three simple operations are required—preparing the trench, placing the culvert in position, and back-filling. Sections are quickly made into long lengths by means of the Toncan Joining Band. They are easy to handle. They are light, strong, and will not crack or break during shipment or installation. They are not affected by expansion or contraction, nor by vibration, impact or earth movements, a marked advantage over culverts of the rigid type. This means the elimination of many costly replacements in service.

SIZES AND TYPES

Toncan Iron Corrugated Culverts are available in diameters from 6 inches to 84 inches, in all standard gauges, and in lengths in multiples of 2 feet. Toncan Perforated Culverts are available in diameters from 6 inches to 30 inches, and in gauges from 16 to 14. Connection between lengths is effected by means of the Toncan Joining Band, a method that is simplicity itself.

For the convenience of the engineer in designing storm and sanitary sewers, under-drains and special culvert layouts. Toncan Iron fittings such as tees, wyes, ells, reducers, crosses and special angles of welded construction are available.

Toncan Part Circle Culverts can be furnished in several different types for concrete base or with Toncan Sheet Base.

For large drainage structures and bridges, Toncan Sectional Plate Pipe may be had in diameters up to 150 inches and in gauges 7 to 1. Simplicity of design and uniformity of fabrication guarantee low cost erection, maximum consistent strength, practical drainage efficiency and high salvage value. Toncan Sectional Plate Pipe is also available for arch construction.

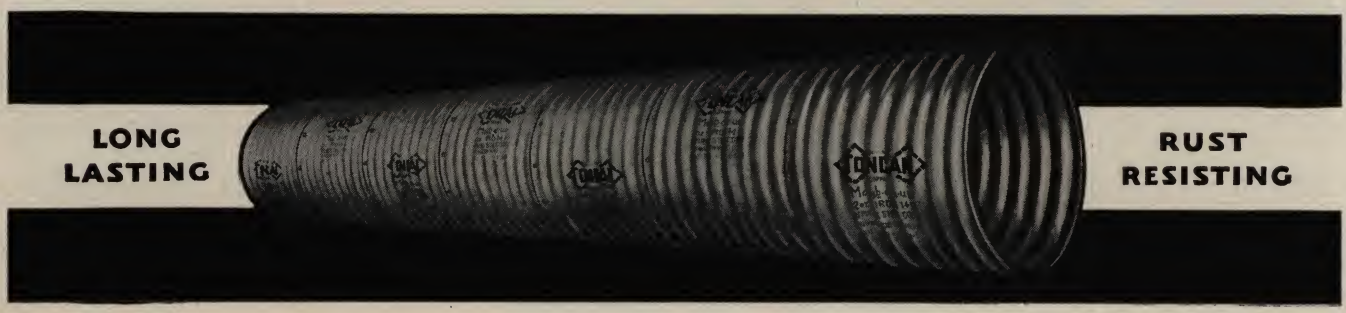
Toncan Iron Culvert Manufacturers are also able to supply Tyton Sluice Gates for the prevention of back flow. They may be had to fit any culvert from 8 inches to 36 inches in diameter. Installation is a simple matter.

USES

Toncan Iron Culverts are ideal for use under highways, city streets, airports, parks, athletic fields, railroad fills, playgrounds, golf courses, as storm sewers, stream enclosures, to replace small bridges—wherever strong, long-lasting, economical drainage structures are needed.

LITERATURE

Complete literature giving full information and engineering details on Toncan Iron Culverts, plain and perforated, fittings, arches, Toncan Sectional Plate Pipe and Tyton Sluice Gates is available, and may be had from your nearest manufacturer upon request.





TYTON
the SAFE HIGHWAY GUARD

1. Posts of the conventional type of wood, concrete or metal may be used.

2. Posts are lined up in the usual way—then drilled to take the spring bolts.

3. Heavy leaf springs of carbon steel, mounted on the posts, support the panels.

4. After all the springs are loosely bolted to the posts, the erection of the panels is easy.

5. The end of one panel telescopes over the end of the next panel.

6. Twelve husky carriage bolts at each panel connection provide ample strength. Bolts passing through spring are left loose until after rail is in proper tension.

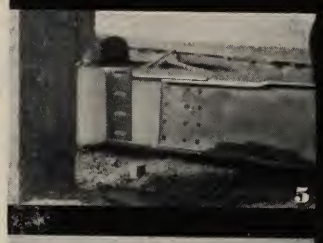
7. The front of the panel provides a smooth surface to guide the vehicle.

8. The post at each end is anchored by the installation of a dead-man.

9. The operation of tightening up the end springs brings the Tyton installation into proper tension.

10. Tightening bolts passing through springs at each panel connection completes the installation.













Safety in highway guard construction must be engineered into its design. That's why Tyton was developed by highway engineers familiar with guard rail requirements.

It can be built to any length and to conform to any road. The panels are bumper high to guide the vehicle out of control until control can be regained. The rolled edges of the panels provide added strength and eliminate sharp dangerous cutting edges. Spring mounting increases the resiliency of the guard and provides plenty of post clearance. Panels are also spring-mounted at the ends.

The simplicity of erection is shown in the progress illustrations. The wider spacing of posts is one reason why the installed cost of Tyton is often no higher than the cost of guard rails of other types of construction that show only a fraction of its strength.

A representative located in your territory is equipped with a technical report outlining a very comprehensive series of highway guard tests conducted by the Pittsburgh Testing Laboratories. Upon request, he will be glad to call on you to explain the results and merits of guards now available. Write today.



A typical installation of Tyton Highway Guard illustrates the ease with which Tyton conforms to road requirements.

Write to your nearest Toncan Culvert Manufacturer (see list at top of opposite page) for full details and prices on the Tyton Highway Guard.

NOTE—Complete Engineering Service is Available at No Additional Cost.



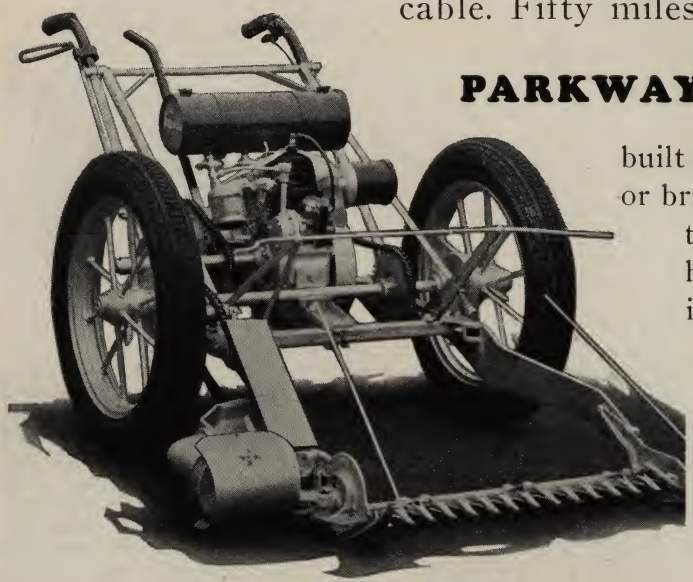
Extension provided for cutting behind Guard Rails

TORO HIGHWAY MOWER

Solves Highway Mowing Problem

An independent power-driven mowing outfit, easily attached to any make of truck with a universal coupling and telescope pipe set at various lengths, and two guide chains. Complete outfit takes up less than half of the pavement.

Extreme flexibility makes this Toro outfit so practical, efficient and fast for highway mowing. The sickle bar operates at every conceivable cutting angle. By simply extending the telescope pipe, it will cut the down slope, the ditch and up slope as well as the shoulder. All of this cutting is handled from the truck, driving along on the highway proper. Two men do the work. One drives the truck and the other raises and lowers the sickle bar with a worm gear lifting device and cable. Fifty miles a day can be made easily.



Parkway Sickle Bar Mower

PARKWAY Sickle Bar MOWER

built especially for cutting weeds, hay or brush up to ¾-inch diameter. Positive traction on rough ground or hills, brute strength and durability, easy operation.

Write for full information.

Toro Manufacturing Co.
3042-3210 Snelling Ave.
MINNEAPOLIS, MINN.

TORO
ALL OVER THE WORLD

TRUSCON STEEL COMPANY

YOUNGSTOWN, OHIO

Manufacturers of Highway Products

BRANCH OFFICES IN THE FOLLOWING CITIES

Albany, N. Y.
Altoona, Pa.
Atlanta, Ga.
Baltimore, Md.
Birmingham, Ala.
Boston, Mass.
Bronxville, N. Y.
Buffalo, N. Y.
Charleston, W. Va.
Chattanooga, Tenn.
Chicago, Ill.
Cincinnati, Ohio
Cleveland, Ohio
Columbus, Ohio
Dallas, Texas
Dayton, Oho
Des Moines, Iowa
Detroit, Mich.
Greensboro, N. C.
Harrisburg, Pa.
Houston, Tex.
Indianapolis, Ind.
Jacksonville, Fla.
Kansas City, Mo.
Little Rock Ark.
Los Angeles, Calif.
Memphis, Tenn.
Milwaukee, Wis.
Minneapolis, Minn.
Newark, N. J.
New Haven, Conn.
New Orleans, La.
New York City, N. Y.
Norfolk, Va.
Omaha, Nebr.
Philadelphia, Pa.
Phoenix, Ariz.
Pittsburgh, Pa.
Portland, Ore.
Richmond, Va.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Calif.
Scranton, Pa.
Syracuse, N. Y.
Toledo, Ohio
Washington, D. C.

Railroad Department, Chicago, Ill.

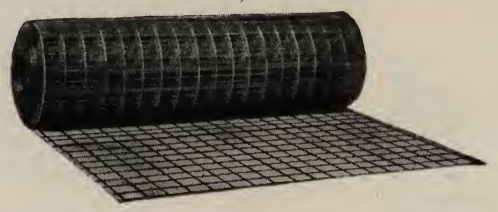
Foreign Trade Department, New York, N. Y.

PRODUCTS—Reinforcing Products for Every Highway Need: Welded Steel Fabric, Expansion Joints, Contraction Plates, Curb Bars, Road Forms, Rib Bars, Duraguard.

TRUSCON HIGHWAY PRODUCTS

The Truscon organization of skilled Highway Engineers are located in above cities to assist you in solving your paving problems. Complete information sent on request.

Truscon Welded Steel Fabric



This ideal mesh reinforcement for concrete is easily installed, increases the life of the pavement and saves money in maintenance. Stays where placed and insures accurate distribution of steel. All cross members welded at intersections. Made in various weights, in flat sheets or rolls.

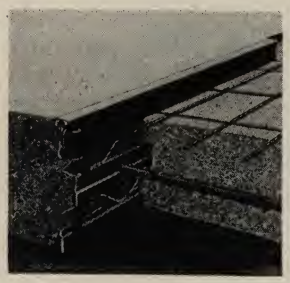
Truscon Steel Road Forms



Exceptionally strong and simple in design. The sliding connections assure perfect alignment and their ample dimensions give long life. Many improvements cut costs and speed construction of roads.

Truscon Expanded Contraction Plates

Expanded Contraction Plates provide definite planes of weakness in pavements that form regular cracks when the concrete expands or contracts. One slab cannot rise above those adjacent to it, due to the design of the plates. A removable cap plate can be placed over the top edge of the contraction plate, which later can be removed and the space filled with bituminous material.



Truscon Rib Bars



Standard steel reinforcing for concrete having a series of cross-ribs designed to secure maximum grip. Square or round types, standard sizes and lengths.

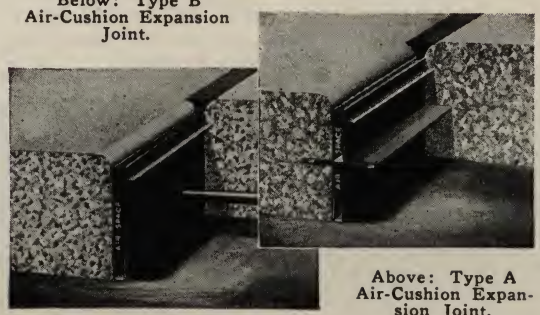
Curb Bars and Edge Protectors

For protecting curbs and columns. Reinforces and protects from abrasion. Positively anchored in concrete. Made in the two sizes of edges, the curb bars having a protecting edge of 1⅝" and the edge protector having an exposed surface of 1". Standard length for both types is 10'.



Air-Cushion Expansion Joints

Below: Type B Air-Cushion Expansion Joint.



Above: Type A Air-Cushion Expansion Joint.

Scientifically efficient, as the joint contracts fully when the pavement expands. No incompressible material in joint. Made in two types, as shown.

Truscon "Duraguard"

Truscon "Duraguard" is designed to withstand a severe shock by absorbing the initial blow of a vehicle and then deflecting it to a position parallel to the construction so that its momentum may be checked easily. Plates are 12" wide, of a gauge of steel as specified. Standard lengths: intermediate sections 15'-11¾", end sections 7'-1⅝", unless other lengths are specified. Posts may be steel, concrete or wood. Easily assembled and erected. Provides high visibility both day and night. "Duraguard" also adaptable as a Bridge Hub Guard, and is attached directly to the existing bridge uprights.



TUTHILL HIGHWAY GUARD

Manufactured and Sold by

TUTHILL SPRING COMPANY

760 Polk Street, CHICAGO, ILL.

Tuthill Resilient Steel Highway Guard



View Showing
Safety-Visibility of
Tuthill Highway Guard

General Information

Modern highways are built to enable motorists to travel from one place to another with speed, comfort and safety. Older types of highways are being improved to accomplish this purpose. Excellent surfaces, fine fills and good grades cannot alone provide the highway user with absolute safety.

Protection of danger spots is an important requisite.

Practical experience has proven that steep shoulder grades, sharp curves, bridge approaches and similar spots require protection to insure careless drivers or cars out of control from leaving the highway at these points.

Many types of highway fencing have been tried, but have proven faulty in some or many instances. Fencing that stops the vehicle suddenly, enmeshes it, or splinters, causes harm comparable with possible damage to the vehicle leaving the road. In many instances the sudden stop causes severe injury or death to the occupants of the vehicle.

Tuthill Highway Guard is the development of favorable factors in guard fence design in one all-metal, resilient, efficient and economical highway guard that will allow a vehicle to hit it and continue on the highway with a minimum of damage.

When an automobile strikes Tuthill Highway Guard the bumper action of the spring rail support immediately deflects the vehicle back onto its path on the road. The strong spring support for the convex rail carries the force of the vehicle's impact to the base of the post, with the resultant action of absorbing the impact at the ground, and not breaking the post as is probable where the spring action is at the top of the post.

Please Send for Complete Data Now

Specification Details

See Drawings Based on 12 in. Wide Guard, Below.

RAILS

5/32–in. x 12–in. for 10–ft. 0–in. centers; or No. 12 ga. x 12–in. for 16–ft. 0–in. centers, .40–.50 carbon steel, hot rolled, cold formed.

Average of 18 Laboratory Tests

Yield Point.....58,272 lbs. per square inch
Tensile Strength.....92,689 lbs. per square inch
Per cent Elongation in 2 in..... 25.4
Rockwell "B" Test..... 87

SPRING SUPPORTS

7/16–in. x 4–in. S.A.E. 1,035 spring steel, tempered. Tensile Strength—110,000 lbs. per square inch.

SUPPORT BOLTS

⅝–in. x 9½–in. Machine Bolts; or length dependent upon size posts.

RAIL BOLTS

⅝–in. x 1⅜–in. Button Head Machine Bolts.

POSTS

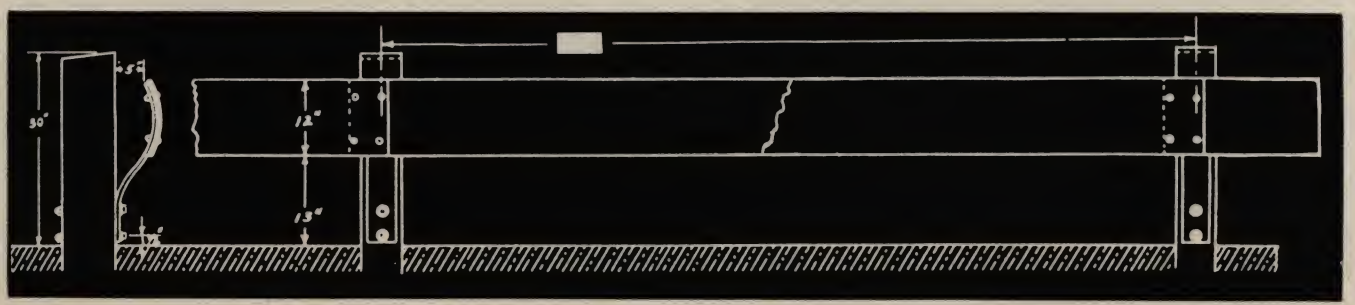
Any standard posts drilled for support springs.
Recommend 10–ft. 0–in. centers.

WEIGHT

5/32–in. x 12–in. x 10–ft. 0–in.....
.....7½lbs. per foot complete with fittings
No. 12 ga. x 12–in. x 16–ft. 0–in.....
.....6½ lbs. per foot complete with fittings

The above specifications cover standard Tuthill Guard, but special designs are available. Post spacings up to 16 ft. 0 in.; with rails of No. 12 gauge or heavier can be furnished from stock. Let us quote on your specifications.

A standard specification for states, counties or municipalities has been prepared. A copy will be sent gratis.



UNITED STATES PIPE AND FOUNDRY CO.

Burlington, N. J.

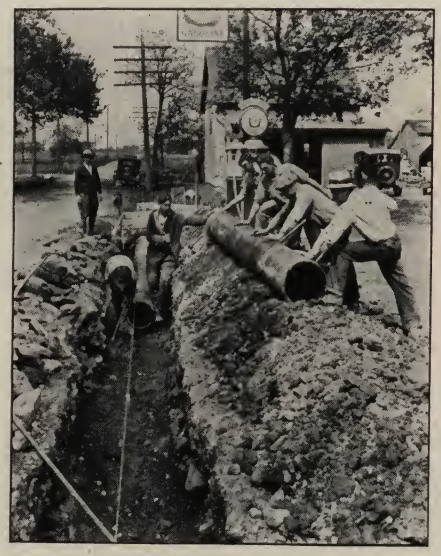
SALES OFFICES:

New York, Philadelphia, Pittsburgh, Buffalo, Cleveland, Washington, D. C., Chicago, Dallas, Birmingham, Kansas City, Boston, Minneapolis, Seattle, San Francisco, Los Angeles

When and why should you specify Cast Iron Culverts for Highways? Just as there are times which call for certain kinds of actions, so are there conditions which call for certain kinds of materials. Everyone agrees that secondary roads call for secondary materials. But, first-class, permanent, improved roads deserve first-class construction materials including culverts of durable cast iron.

U. S. Cast Iron Culverts are consistent with the policy of permanence in the building of our modern highways. The long life of U. S. Cast Iron Culverts is an important factor in reducing the cost of highway transportation per vehicle mile. U. S. Culverts have strength and to spare to stand up under heavy embankment loads.

There are U. S. Cast Iron Culverts in sizes and lengths to fit practically every requirement. They come in 3 ft., 6 ft., 9 ft., 12 ft. and 18 ft. lengths, and in diameters from 10 inches to 48 inches inclusive.



Special lengths will also be made up to your order. Shipped all ready to put in place, assuring fast and efficient culvert installation in any kind of weather. U. S. Culverts can be placed by unskilled labor without the bother or cost of special rigging.

If you are faced with any unusual road drainage problem, our Engineering Department stands ready at all times to cooperate with you in working out a favorable solution. Information regarding the economy of U. S. Cast Iron Culverts for all improved roads will cheerfully be supplied. Address Culvert Division, United States Pipe and Foundry Co., Burlington, New Jersey.

The U. S. Cast Iron Highway Culvert Book gives a fund of information regarding U. S. Cast Iron Culverts. Illustrated with charts and actual photographs. A book every highway engineer should have in his file. Write for free copy.

Sizes and Weights of U. S. Cast Iron Highway Culverts

Nominal Diameter	Thickness	3 Feet Length Including Bell		6 Feet Length Including Bell		9 Feet Length Including Bell		12 Feet Length Including Bell	
		Foot	Length	Foot	Length	Foot	Length	Foot	Length
10″	.42″	56.9#	170.6#	53.17#	319#	49.3#	443.4#	48.7#	585#
12″	.46″	66#	199#	62#	371#	64.3#	579.0#	63.7#	765#
14″	.48″	80#	240#	75#	449#	78.8#	709.0#	77.58#	931#
16″	.50″	95#	286#	89#	535#	96.0#	864.0#	94.58#	1135#
18″	.52″	111#	334#	104#	624#	115.8#	1042.0#	113.92#	1367#
20″	.54″	128#	385#	120#	720#	135.5#	1220.0#	133.25#	1599#
24″	.58″	167.6#	503#	155.50#	933#	151.4#	1363.0#	149.42#	1793#
30″	.70″	247.3#	742#	230.00#	1381#	224.5#	2020.2#	222.00#	2659#
36″	.82″	346.6#	1040#	322.50#	1935#	314.5#	2831.0#	310.50#	3726#
42″	.90″	442.0#	1326#	412.00#	2472#	402.0#	3618.0#	396.92#	4763#
48″	.97″	545.6#	1638#	508.33#	3050#	495.9#	4463.0#	489.67#	5876#

Culverts of 10″ to 20″ diameter, of 9′ and 12′ lengths are produced by the deLavaud centrifugal process.
Lock Joint Culvert Pipe manufactured by the pit cast process also available in the above sizes and lengths.

UNIVERSAL CRUSHER COMPANY

623 C Ave. W., Cedar Rapids, Iowa

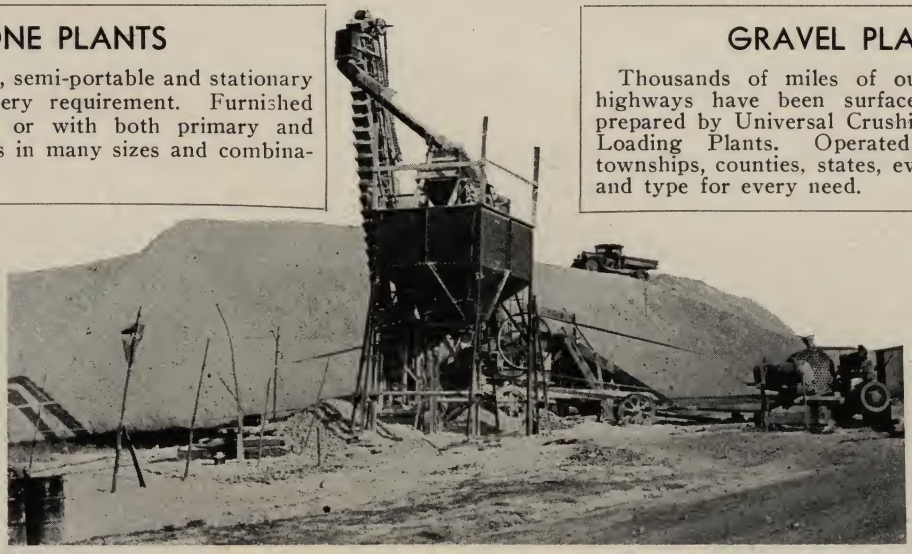
PRODUCTS: Jaw Crushers, Crushing Rolls, Hammer Pulverizers, Unit and Dual Crushing, Screening and Loading Plants, Bucket and Belt Conveyors, Bins, Gyrating and Revolving Screens

STONE PLANTS

Built in portable, semi-portable and stationary types to meet every requirement. Furnished with one crusher or with both primary and secondary crushers in many sizes and combinations.

GRAVEL PLANTS

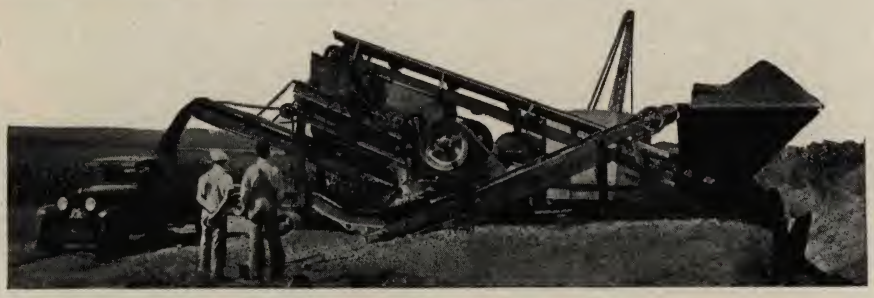
Thousands of miles of our finest graveled highways have been surfaced with materials prepared by Universal Crushing, Screening and Loading Plants. Operated by contractors, townships, counties, states, everywhere. A size and type for every need.



A 12,000 yard stock-pile was quickly built up with this semi-portable Crushing, Screening and Loading Plant. 15x36" primary crusher, 30"x16" secondary crushing rolls and the needed auxiliary equipment to make the plant complete.



A roadside crushing plant complete with screen and bin. Many hundreds of miles of county, township and state roads have been surfaced with plants like this.



Straight Line operated gravel plant. From shovel or dragline to truck in one operation. Built for one or two crusher operation with capacities to meet individual needs. Size crusher furnished to suit oversize in pit. Plant capacities up to 1500 yards 10 hours.

CWA and PWA projects and local unemployment relief work throughout the United States, turned to Universal Crushers and Crushing Plants for quick, effective and permanent results.



Floyd County, Iowa, found this plant to be a valuable asset to its relief program. 1,000 yards is an easy 10 hours work for this plant.

STEEL CRUSHERS



Secondary Sizes:
8x10", 8x12", 9x16"
8x18", 8x24", 9x36"

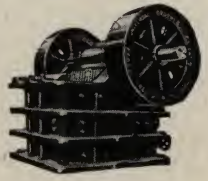
The **Universal force-feed crusher** is the oldest of its type manufactured today. Its success and steady advance have continued for 27 years, during which time it has gained wide-spread recognition in the industry.

Features: Unusual simplicity, force-feed jaw action, two crushing strokes to each shaft revolution, only three bearings, these removable and dust-proof, reversible manganese steel jaw plates, protective toggle plate, quick accurate adjustment for any finished size and a jaw action which produces an extraordinarily uniform product.

Big Variety—From 26 sizes, it is possible to select a crusher exactly suited to the job. There is almost no limit to the number of combinations which can be made up to fit different requirements. Give us details regarding your problem.

EXPERT ENGINEERING SERVICE. ASK FOR COMPLETE CATALOG.

STEEL CRUSHERS



Primary Sizes:
12x20", 12x24", 12x36"
15x20", 15x24", 15x36"

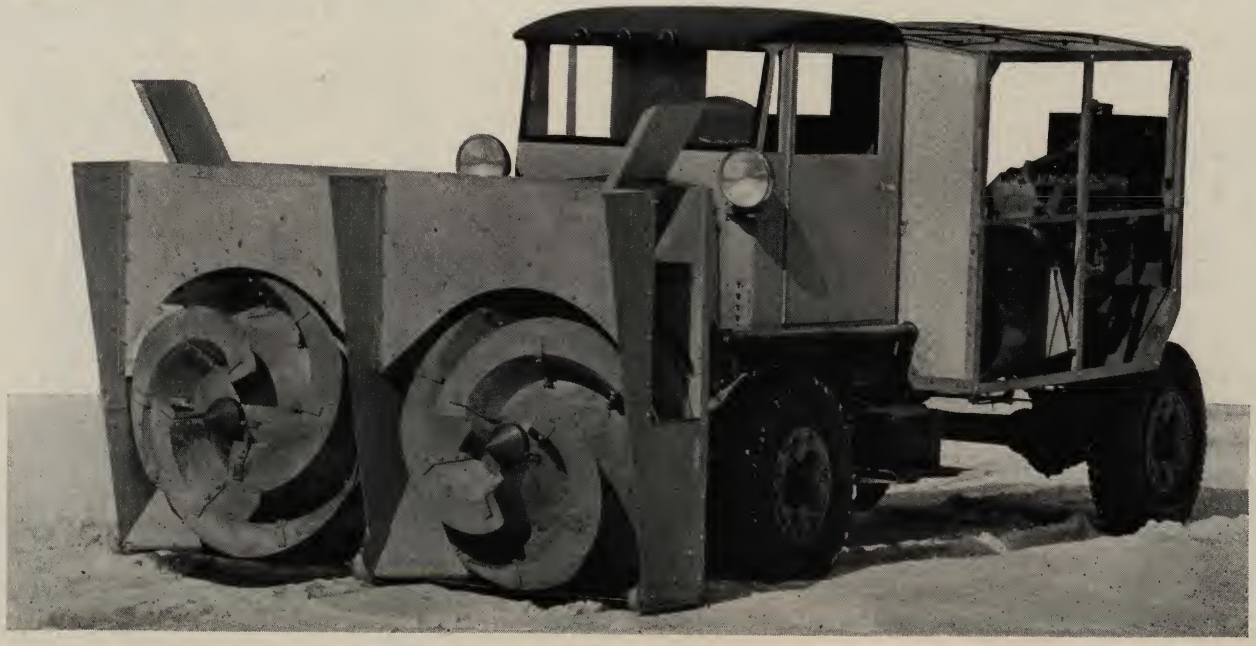
ZAREMBA SNOW ROOTERS

29 E. Market St., Buffalo, N. Y.

CABLE ADDRESS
SNOROOTER — BUFFALO

Apparatus for Heavy-Duty Snow-Removal from Highways

Highway Officials—What does it profit to spend thousands in quickly clearing miles and miles of roadway only to have traffic hung-up by relatively short but deep, dense, devilish snowdrifts. No over, no under, no detour to either side—the only way is straight thru—but how? The answer to this question is



THE ZAREMBA SNOW-ROOTER

A rotary snow-shovel designed for opening-up snowdrifts, removing roadside banks and performing other heavy-duty removal work. It is the battleship of the snow-removal fleet.

FEATURES:

1—The ZAREMBA SNOW ROOTER **provides ample power** for any situation—80 H.P. for each rotor, 80 H.P. for the truck; three engines independently controlled—240 H.P. in all.

2—Power is applied with **highest efficiency** by means of two rotors (propeller-impeller turbines) adjustable to the condition of the snow—this together with

3—Independent control of speed of either rotor and of truck-speed provides means of adaptation of rooter action to **varying conditions** of snow-density, height of lift, force of wind and proper position for landing snow.

4—Snow can be **discharged beyond side-ditches** so that (2) no banks are formed and (b) shoulders of road are protected from melting snow.

5—Rotor-speeds can be increased to throw extra high snow-stream in **clearing deep cuts** free from snow.

6—Controlled discharge **safeguards buildings** along roadside.

7—**No hold-ups** in forward movement of truck due to packing of snow in front. No slowing up due to clogging of outlet by discharged snow.

8—**No surging** of snow over apparatus before rotors can entrap it.

9—Operations are conducted steadily and **without bucking**—hence neither apparatus or operators are exposed to injury from shock.

10—By adjustment of speeds used the discharged snow can be scattered sufficiently to **avoid formation of "drift-traps"** for future storms.

11—Rotors can be raised permitting truck to **travel quickly** to location of drift.

12—Mechanism consists of few and **simple elements**, simply combined and easily reached.

13—ZAREMBA SNOW ROOTERS can be **mounted on any four-wheel-drive truck** without alteration, and removed from same at end of season.

14—**Patroling** is for light-duty, high-speed plows; **opening** of blocked highways is for heavy-duty, low-speed shovels. Use Zaremba Snow Rooters for your **opening and shoveling**—thereby releasing your plows for their proper work of **patroling.**

15—The use of Zaremba Snow Rooters **eliminates the damage** and danger resulting from the ramming tactics imposed on high-speed plows where forced to do heavy-duty work.

Once Over and That Snow Is Out for the Season

DETAILS ARE YOURS FOR THE ASKING

Month After Month

ROADS AND STREETS

Helps Solve Your Problems

24 GREAT ISSUES *for* $3

IT is no secret that meeting competition and changing conditions is a real problem today.

That is why we feel sure you will want to read Roads and Streets every month with its NEWS of new ideas—new methods and new equipment.

Roads and Streets is written for you by practical men with a first-hand knowledge of the field and your needs. They dig right down to the bottom of every problem and present the solution in a clear, concise manner that you will understand and be able to apply to your work.

This is the kind of practical information that 20,000 alert, progressive readers of Roads and Streets now are finding so valuable to them—and the reason why they renew their subscriptions year after year.

Roads and Streets deserves a prominent place on your reading program—it is one investment you can't afford NOT to make. You won't miss 3c a week, and that is all it costs, and you shouldn't miss the valuable, usable information each issue contains.

•

Subscribe Now!

Pin your check for $3 to your letterhead and mail to

ROADS AND STREETS

A Gillette Publication

400 West Madison Street, Chicago, Ill.

2-YEAR SUBSCRIPTION IN FULL



USE THESE FORMS WHEN ORDERING BOOKS

1—Construction Cost-Keeping and Management

GILLETTE PUBLISHING COMPANY
400 West Madison St., Chicago, Illinois

Please send me postpaid Construction Cost Keeping and Management. In ten days I agree to return the book postpaid or remit $5.00 in full payment.

Name .....

Position or Business.....

Address .....

City..... State.....

P.R.R.

2—Handbook of Cost Data

GILLETTE PUBLISHING COMPANY
400 West Madison St., Chicago, Illinois

Please send me postpaid Handbook of Cost Data. In ten days I agree to return the book postpaid or remit $6.00 in full payment.

Name .....

Position or Business.....

Address .....

City..... State.....

P.R.R.

3—Engineers' Vest Pocket Book

GILLETTE PUBLISHING COMPANY
400 West Madison St., Chicago, Illinois

Please send me postpaid Engineers' Vest Pocket Book. In ten days I agree to return the book postpaid or remit $3.00 in full payment.

Name .....

Position or Business.....

Address .....

City..... State.....

P.R.R.

4—Labor Costs of Construction

GILLETTE PUBLISHING COMPANY
400 West Madison St., Chicago, Illinois

Please send me postpaid Labor Costs of Construction. In ten days I agree to return the book postpaid or remit $3.00 in full payment.

Name .....

Position or Business.....

Address .....

City..... State.....

P.R.R.

5—Economics of Construction Management

GILLETTE PUBLISHING COMPANY
400 West Madison St., Chicago, Illinois

Please send me postpaid Economics of Construction Management. In ten days I agree to return the book postpaid or remit $3.75 in full payment.

Name .....

Company .....

Address .....

City..... State.....

P.R.R.

6—Low-Cost Roads and Bridges

GILLETTE PUBLISHING COMPANY
400 West Madison St., Chicago, Illinois

Please send me postpaid Low Cost Roads and Bridges. In ten days I agree to return the book postpaid or remit $6.00 in full payment.

Name .....

Position or Business.....

Address .....

City..... State.....

P.R.R.

7—Methods and Costs Library

GILLETTE PUBLISHING COMPANY
400 West Madison St., Chicago, Illinois

Please send me the Methods and Costs Library, postpaid, for examination. In 10 days I will remit $6.90 in part payment and keep the books or I will return them postpaid. If I keep them you agree to send me a free copy of "Cost Keeping and Management." I will send $4.00 a month for 5 months until the full price, $26.90, is paid.

Name .....

Position or Business.....

Address .....

City..... State.....

P.R.R.

8—Road Builders' Library

GILLETTE PUBLISHING COMPANY
400 West Madison St., Chicago, Illinois

Please send me postpaid the Road Builders' Library. In ten days I will return the books or send you $5.00 in part payment and keep the books. Thereafter each following month for 4 months I will send you $4.00 until the full price of $21.00 is paid.

Name .....

Position or Business.....

Address .....

City..... State.....

P.R.R.

FOR USERS OF THIS CATALOGUE

When writing any of the firms listed in this volume, it will be of mutual advantage to cut out and enclose one of these blanks.

Date.....19.....

To .....

Gentlemen: Referring to your listing in Powers' Road and Street Catalog, please send the following information.....

.....

.....

.....

.....

Name .....

Address .....

Business .....

Date.....19.....

To .....

Gentlemen: Referring to your listing in Powers' Road and Street Catalog, please send the following information.....

.....

.....

.....

.....

Name .....

Address .....

Business .....

Date.....19.....

To .....

Gentlemen: Referring to your listing in Powers' Road and Street Catalog, please send the following information.....

.....

.....

.....

.....

Name .....

Address .....

Business .....

Date.....19.....

To .....

Gentlemen: Referring to your listing in Powers' Road and Street Catalog, please send the following information.....

.....

.....

.....

.....

Name .....

Address .....

Business .....

Date.....19.....

To .....

Gentlemen: Referring to your listing in Powers' Road and Street Catalog, please send the following information.....

.....

.....

.....

.....

Name .....

Address .....

Business .....

Date.....19.....

To .....

Gentlemen: Referring to your listing in Powers' Road and Street Catalog, please send the following information.....

.....

.....

.....

.....

Name .....

Address .....

Business .....

Date.....19.....

To .....

Gentlemen: Referring to your listing in Powers' Road and Street Catalog, please send the following information.....

.....

.....

.....

.....

Name .....

Address .....

Business .....

Date.....19.....

To .....

Gentlemen: Referring to your listing in Powers' Road and Street Catalog, please send the following information.....

.....

.....

.....

.....

Name .....

Address .....

Business .....

HIGHWAY INDUSTRY SECTION - - - -

AMERICAN ROAD BUILDERS' ASSOCIATION

Organized 1902, Incorporated 1910 under the
Laws of the State of New York

NATIONAL PRESS BUILDING, WASHINGTON, D. C.

BOARD OF DIRECTORS OF THE AMERICAN ROAD BUILDERS' ASSOCIATION

EXECUTIVE OFFICERS

PRESIDENT
H. C. Whitehurst
Director of Highways
District of Columbia
Washington, D. C.

SECRETARY
Chas. M. Upham
Washington, D. C.

TREASURER
James H. MacDonald
Consulting Road and Paving Expert
New Haven, Conn.

VICE PRESIDENT, Northeastern District
E. L. Benedict
E. L. Benedict and Associates
Pittsburgh, Pa.

VICE PRESIDENT, Southern District
Chas. M. Upham
Engineer-Director, A. R. B. A.
Washington, D. C.

VICE PRESIDENT, Central District
Grover C. Dillman
Director of Public Service
Grand Rapids, Michigan

VICE PRESIDENT, Western District
Stanley Abel
Supervisor, Fourth District
Kern County, Taft, Calif.

PAST PRESIDENTS
Wm. R. Smith
President, Lane Construction Corporation
Meriden, Conn.

T. H. Cutler
Chief Engineer, Missouri State Highway Dept.
Jefferson City, Mo.

DIRECTORS
(Term Expires 1935)

J. H. Cranford
President, Cranford Paving Company
Washington, D. C.

Arthur W. Dean
Chief Engineer, Massachusetts Department of Public Works
Boston, Mass.

E. J. Harding
Managing Director, Associated General Contractors of America, Inc.
Washington, D. C.

J. S. Helm
General Manager, Asphalt Sales Department, Standard Oil Company of New Jersey
New York, N. Y.

A. E. Horst
Secretary-Treasurer, Henry W. Horst Co.
Philadelphia, Pa.

George B. Sowers
Consulting Engineer
Cleveland, Ohio

Chas. T. Hvass
President, Chas. T. Hvass Company
New York, N. Y.

DIRECTORS
(Term Expires 1936)

T. J. Mahony
Chairman, Highways Advisory Board
Province of Ontario, Toronto, Ontario, Canada

Otto S. Hess
Engineer-Manager, Kent County Road Commission
Grand Rapids, Mich.

H. J. Kaiser
Kaiser Paving Company
Oakland, Cal.

W. M. Kinney
General Manager, Portland Cement Association
Chicago, Ill.

Wm. P. McDonald
Wm. P. McDonald Construction Company
New York, N. Y.

George F. Schlesinger
Chief Engineer and Managing Director, National Paving Brick Association
Washington, D. C.

Carl O. Wold
Vice President, Caterpillar Tractor Company
Peoria, Ill.

DIRECTORS
(Term Expires 1937)

Robert B. Brooks
Consulting Engineer
St. Louis, Mo.

Paul L. Griffiths
Vice President, Koppers Products Co.
Pittsburgh, Pa.

A. Lee Grover
Secretary, New Jersey State Highway Dept.
Trenton, N. J.

L. B. McLeod
President, L. B. McLeod Construction Co.
Williston, Fla.

J. E. Pennybacker
Managing Director, The Asphalt Institute
New York, N. Y.

George C. Stanley
City Engineer
Burlington, Vt.

J. Borton Weeks
President, Keystone Automobile Club
Philadelphia, Pa.

ORGANIZATION AND HISTORY

The American Road Builders' Association was organized in 1902. The object of the Association is scientific and technical and its purpose is to acquire and disseminate information concerning highway construction, maintenance, operation and finance; to stimulate interest in the subject of good roads and to promote educational, legislative and other measures on behalf of highway development. In the 27 years of its existence the Association has grown to be the leading organization in its field, including as it now does every interest identified with road and street building in all countries. It represents the constructor and the operator of the highway, as well as the user; it is strictly non-commercial in character, devoting its revenue to the furtherance of the aims and objects for which it was organized and it is recognized as the leading authority on all matters relating to highway and street improvement.

In order to adequately carry on its educational and scientific work, the American Road Builders' Association has classified its membership; the various groups now being included in the following eight Divisions:

County Highway Officials' Division.
City Officials' Division.
Engineers' and Officials' Division.
European Division.
Highway Contractors' Division.
Manufacturers' Division.
Membership-at-Large Division.
Pan American Division.

The work is being carried out by these Divisions through 58 committees. These committees cover the various phases of highway and street construction, maintenance and operation as related to their particular fields and they are being assisted in their research and scientific investigations by the engineering staff of the Association.

BOARD OF DIRECTORS OF THE COUNTY HIGHWAY OFFICIALS' DIVISION

AMERICAN ROAD BUILDERS' ASSOCIATION

EXECUTIVE OFFICERS

PRESIDENT
E. L. Gates
County Supt. of Highways
DuPage County
Wheaton, Ill.

VICE PRESIDENT, Northeastern District
J. A. Bromley
County Roads Engineer, Anne Arundel County
Annapolis, Md.

VICE PRESIDENT, Southern District
C. C. Thacker
Secretary, Davidson County Highway Commission
Nashville, Tenn.

SECRETARY
Chas. M. Upham
Engineer-Director, A. R. B. A.
Washington, D. C.

VICE PRESIDENT, Central District
J. W. Mavity
County Engineer, Harvey County
Newton, Kansas

VICE PRESIDENT, Western District
Stanley Abel
Supervisor, Fourth District, Kern County
Taft, Calif.

TREASURER
James H. MacDonald
Treasurer, A. R. B. A.
New Haven, Conn.

PAST PRESIDENTS
Hal G. Sours
County Engineer, Summit County
Akron, Ohio

W. O. Washington
County Engineer, Cameron County
Brownsville, Texas

DIRECTORS
(Term Expires 1935)

J. T. Bullen
Parish Engineer, Caddo Parish
Shreveport, La.

J. A. Bromley
County Roads Engineer
Anne Arundel County
Annapolis, Md.

Ben T. Collier
County Engineer, Coahoma County
Clarksdale, Miss.

Chas. W. Deterding
County Engineer, Sacramento County
Sacramento, Calif.

Don Heaton
County Surveyor, Benton County
Fowler, Ind.

Roy Jablonsky
County Surveyor, St. Louis County
Clayton, Mo.

George C. Wright
County Superintendent of Highways
Monroe County
Rochester, N. Y.

DIRECTORS
(Term Expires 1936)

H. M. Clark
County Roads Engineer, Wicomico County
Wicomico County
Salisbury, Md.

Paul N. Coates
County Engineer, Ramsey County
St. Paul, Minn.

W. E. Duckett
County Highway Engineer, Hennepin County
Minneapolis, Minn.

E. C. Gwillim
County Surveyor, Sheridan County
Sheridan, Wyo.

Arthur Hargreaves
County Highway Superintendent, Douglas County
Armour, S. D.

R. C. Hill
County Engineer, Sussex County
Georgetown, Del.

John J. McHugh
Deputy Clerk, Board of Chosen Freeholders
Hudson County
Jersey City, N. J.

DIRECTORS
(Term Expires 1937)

R. D. Alverson
County Engineer, Snohomish County
Everett, Washington

H. G. Culverhouse
Supt. of Roads, Jefferson County
Birmingham, Ala.

L. P. M. Gaylord
County Supt. of Highways, Lewis County
Lowville, New York

Otto S. Hess
Engineer-Manager, County Road Commission
Kent County
Grand Rapids, Mich.

H. B. Keasbey
Counselor-at-Law
Salem, N. J.

J. C. McLean
County Engineer, Woodbury County
Sioux City, Iowa

L. O. Marden
County Engineer, Worcester County
Worcester, Mass.

BOARD OF DIRECTORS OF THE CITY OFFICIALS' DIVISION

AMERICAN ROAD BUILDERS' ASSOCIATION

EXECUTIVE OFFICERS

PRESIDENT
Bryson Vallas
General Supt., Sewerage and Water Board
New Orleans, La.

VICE PRESIDENT, Northeastern District
Dudley T. Corning
Chief, Bureau of Highways
Philadelphia, Pa.

VICE PRESIDENT, Southern District
H. D. Palmore
City Manager
Covington, Ky.

SECRETARY
Chas. M. Upham
Engineer-Director, A. R. B. A.
Washington, D. C.

VICE PRESIDENT, Central District
J. M. Tippee
City Engineer
Des Moines, Iowa

VICE PRESIDENT, Western District
J. C. Albers
City Engineer
Glendale, Calif.

TREASURER
James H. MacDonald
Treasurer, A. R. B. A.
Washington, D. C.

PAST PRESIDENTS
Robert B. Brooks
Consulting Engineer
St. Louis, Mo.

B. Keith Compton
Director of Public Works
Richmond, Va.

The ultimate purpose of the committee activities is the compilation and practical application of specifications, definite standards and recommended practices covering the equipment, materials and methods used in street and highway construction, maintenance, operation and finance.

The membership of these committees is composed of leading authorities in their respective lines.

ANNUAL CONVENTION

Each year the Association holds its annual convention, bringing together more than 25,000 road builders from all the states, counties and cities of the United States, as well as from these various foreign countries. This attendance includes, in addition to the engineers, officials and contractors, official delegates appointed by the various countries in South and Central America, as well as a large number of official delegates from the several European countries. At the convention the committees submit their reports covering the year's work in investigation and research, presenting the latest methods and standards, together with conclusions and recommendations. These reports are open for discussion by everyone interested and at the close of the convention are printed in the official proceedings of the Association and sent to the membership.

ANNUAL ROAD SHOW

In connection with the convention, the Association holds an exposition or road show, which is the world's largest and most comprehensive exhibition and demonstration of road and street building machinery, materials and methods. All the latest developments in equipment and materials are made available for inspection and comparison at this exposition. An unparalleled opportunity is thus afforded those making up their highway programs for the coming year—the exposition is an event looked forward to by the entire industry.

DIRECTORS
(Term Expires 1935)

W. E. A. Doherty
Engineer of Construction, Bureau of Highways
Philadelphia, Pa.

M. O. Eldridge
Assistant Director of Traffic
Washington, D. C.

O. Laurgaard
Consulting Engineer
Portland, Ore.

M. M. O'Shaughnessy
Consulting Engineer
San Francisco, Calif.

Albert T. Rhodes
City Councilor
Leominster, Mass.

W. E. Sheddan
City Engineer
Jacksonville, Fla.

Nathan L. Smith
Associate Engineer, Department of Public Works
Baltimore, Md.

DIRECTORS
(Term Expires 1936)

J. C. Albers
City Engineer
Glendale, Calif.

H. D. Bradley
Deputy Street Commissioner
Toronto, Canada

Merrill D. Knight
City Engineer
Lynchburg, Va.

H. H. Kranz
Engineer of Highways
Cincinnati, O.

E. E. Parker
City Engineer
Madison, Wis.

Harry L. Shaner
Commissioner of Public Works
Winston-Salem, N. C.

Albion K. Vickery
City Engineer
Denver, Colo.

DIRECTORS
(Term Expires 1937)

Wm. N. Carey
Minnesota State Engineer
Public Works Administration
St. Paul, Minn.

Walter N. Frickstad
City Engineer
Oakland, Calif.

P. W. Maetzel
Chief Engineer, Department of Public Service
Columbus, Ohio

Frank J. McDevitt
Director, Streets and Sewers
St. Louis, Mo.

A. E. Roche
Commissioner of Public Works
Troy, New York

J. E. Root
Director, Department of Public Works
Cincinnati, Ohio

Geo. C. Stanley
City Engineer
Burlington, Vt.

MANUFACTURERS' DIVISION

(Incorporated as the Highway Industries Association)

EXECUTIVE COMMITTEE

W. T. Chevalier **C. B. Smythe** **G. F. Schlesinger** **C. M. Upham** **W. A. Olen** **Wm. M. Parrish**

EXECUTIVE OFFICERS

PRESIDENT
Willard T. Chevalier
Vice President, McGraw-Hill Publishing Co.
New York, N. Y.

VICE PRESIDENT
Chauncey B. Smythe
Vice President, the Thew Shovel Co.
Lorain, Ohio

EXECUTIVE SECRETARY
Charles M. Upham
Engineer-Director
American Road Builders' Assn.
Washington, D. C.

SECRETARY AND TREASURER
G. F. Schlesinger
Managing Director, National Paving Brick Assn.
Washington, D. C.

DIRECTORS

S. F. Beatty
President, Austin-Western Road Mach'y Co.
Chicago, Ill.

B. C. Briody
Vice President, Truscon Steel Co.
Youngstown, Ohio

E. M. Fleming
Mgr., Highways and Municipal Bureau
Portland Cement Association
Chicago, Ill.

Lion Gardiner
President, Lakewood Engineering Co.
Columbus, Ohio

Paul L. Griffiths
Vice President, Koppers Products Company
Pittsburgh, Pa.

Guy Kelcey
Sales Manager, Signal Service Corp.
Elizabeth, N. J.

C. H. Lehman
Secretary and Gen. Sales Manager
Blaw-Knox Company
Pittsburgh, Pa.

W. A. Olen
President, the Four Wheel Drive Auto Co.
Clintonville, Wis.

Wm. M. Parrish
Industrial Sales Executive
International Harvester Co. of America
Chicago, Ill.

J. E. Pennybacker
Managing Director, the Asphalt Institute
New York, N. Y.

Henry N. Schramm
President, Schramm, Inc.
West Chester, Pa.

W. H. F. Thompson
Vice President
Pioneer Gravel Equipment Mfg. Co.
Minneapolis, Minn.

ASSOCIATE DIRECTORS

E. J. Harding
Managing Director
Associated General Contractors of America
Washington, D. C.

Frederic W. Matthels
President, Associated Equipment Distributors
Boston, Mass.

THE ASSOCIATED GENERAL CONTRACTORS OF AMERICA

Incorporated

Munsey Building, Washington, D. C.

EXECUTIVE OFFICERS

PRESIDENT
Nick F. Helmers
Vice-Pres., Siems-Helmers, Inc.
St. Paul, Minn.

VICE-PRESIDENT-AT-LARGE
A. W. Merchant
Pres., A. W. Merchant, Inc.
Providence, R. I.

PRESIDENT'S CABINET

Nick F. Helmers
Vice-Pres., Siems-Helmers, Inc.
St. Paul, Minn.

A. W. Merchant
Pres., A. W. Merchant, Inc.
Providence, R. I.

E. P. Forrestel
Pres., Cold Spring Constr. Co.
Akron, New York

A. P. Greensfelder
Pres., Fruin-Colnon Contr. Co.
St. Louis, Mo.

H. P. Treadway
Pres., Kansas City Bridge Co.
Kansas City, Mo.

A. E. Horst
Sec. & Treas., Henry W. Horst Co.
Philadelphia, Pa.

A. C. Tozzer
Exec. Vice-Pres., Turner Constr. Co.
New York, N. Y.

ALTERNATES
Richard Hopkins
Pres., Richard Hopkins Co.
Albany, New York

ALTERNATES
Henry J. Kaiser
Director, Six Companies, Inc.
San Francisco, Calif.

ALTERNATES
B. L. Knowles
Pres., E. D. Ward Company
Worcester, Mass.

George B. Walbridge
Vice-Pres., Walbridge-Aldinger Co.
Detroit, Michigan

David J. White
Treas., Bay State Dredging & Contr. Co.
East Boston, Mass.

VICE-PRESIDENTS
(To serve until 1935)

W. F. Creighton
Pres., Foster & Creighton Co.
Nashville, Tenn.

L. H. Lacy
Pres., L. H. Lacy Co.
Dallas, Texas

M. A. Long
Pres., M. A. Long Co.
Baltimore, Md.

VICE-PRESIDENTS
(To serve until 1936)

J. C. Compton
McMinnville, Oregon

H. P. Treadway
Pres., Kansas City Bridge Co.
Kansas City, Mo.

VICE-PRESIDENTS
(To serve until 1937)

Lynn Atkinson
Mgr., Lynn Atkinson Co.
Los Angeles, Calif.

Wm. L. Collins
Hornell, N. Y.

H. L. Frisinger
Lewis & Frisinger Co.
Ann Arbor, Mich.

DIRECTORS

DIRECTORS
(Past Presidents)

W. A. Rogers
Pres., Bates & Rogers Constr. Co.
Chicago, Ill.

Arthur S. Bent
Partner, Bent Brothers
Los Angeles, Calif.

John W. Cowper
John W. Cowper Co.
Buffalo, N. Y.

Frederick L. Cranford
Pres., Frederick L. Cranford, Inc.
Brooklyn, N. Y.

George B. Walbridge
Vice-Pres., Walbridge-Aldinger Co.
Detroit, Mich.

J. H. Ellison
Chairman of Board, Winston Bros. Co.
Minneapolis, Minn.

T. T. Flagler
Pres., The Flagler Co.
Atlanta, Ga.

A. E. Horst
Sec. & Treas., Henry W. Horst Co.
Philadelphia, Pa.

A. P. Greensfelder
Pres., Fruin-Colnon Contr. Co.
St. Louis, Mo.

Henry J. Kaiser
Director, Six Companies, Inc.
San Francisco, Calif.

A. C. Tozzer
Exec. Vice-Pres., Turner Constr. Co.
New York, N. Y.

DIRECTORS
(To serve until 1935)

Herman Brown
Brown & Root
Austin, Texas

L. S. Corey
Utah Constr. Co.
Salt Lake City, Utah

B. L. Knowles
Pres., E. D. Ward Co.
Worcester, Mass.

H. W. McCurdy
Pres., Puget Sound Bridge & Dredging Co.
Seattle, Wash.

Harry L. Mundy
Pres., A. Guthrie Co., Inc.
St. Paul, Minn.

J. W. Ryan
John W. Ryan Co.
New York, N. Y.

DIRECTORS
(To serve until 1936)

T. J. Baker
Pres., Coddington Engr. Corp.
Milwaukee, Wis.

E. P. Forrestel
Pres., Cold Spring Constr. Co.
Akron, New York

W. R. Hughes
Pres., Hughes-Foulkrod Co.
Philadelphia, Pa.

H. B. Zachary
Pres., H. B. Zachary Co.
Laredo, Texas

DIRECTORS
(To serve until 1937)

H. W. Beers
Southern-Ferro-Concrete Co.
Atlanta, Ga.

A. E. Christensen
Christensen & Gardner
Salt Lake City, Utah

S. K. Jones
S. K. Jones Constr. Co.
Memphis, Tenn.

W. A. Klinger
Pres., W. A. Klinger, Inc.
Sioux City, Iowa

J. B. Ohligschlager
Pres., National Concrete Constr. Co.
Louisville, Ky.

John W. Russell
Doyle & Russell
Richmond, Va.

SECRETARY-TREASURER

Wm. Muirhead
Pres., Wm. Muirhead Constr. Co.
Durham, N. C.

ADVISORY BOARD

W. F. Austin
Pres., W. E. Wood Co.
Detroit, Mich.

E. T. Foley
Foley Bros., Inc.
St. Paul, Minn.

Mason Garber
North Eastern Constr. Co.
Winston-Salem, N. C.

J. E. Gervin
W. A. & J. E. Gervin
Knoxville, Tenn.

Richard Hopkins
Pres., Richard Hopkins Co.
Albany, N. Y.

J. W. Hunt
Henry Hunt, Inc.
Miami, Fla.

C. E. Lott
Pres., John F. Casey Co.
Pittsburgh, Pa.

C. W. Lundoff
Pres., Lundoff-Bicknell Co.
Cleveland, Ohio

J. A. Lyons
Portland, Oregon

B. F. Nelch
B. F. Nelch & Son
Springfield, Ill.

R. E. O'Connor
Pres., J. C. O'Connor & Sons, Inc.
Fort Wayne, Ind.

L. A. Ray
Sec.-Treas., Diamond Engr. Co.
Grand Island, Nebr.

Fred I. Rowe
W. L. Johnson Constr. Co.
Hicksville, Ohio

Chas. A. Shea
J. F. Shea & Company
Portland, Oregon

L. P. Slattery
Pres., Slattery & Henry, Inc.
Greenville, S. C.

H. J. Sternberg
Sternberg Company, Inc.
St. Louis, Mo.

H. S. Tullock
Pres., Missouri Valley Bridge & Iron Co.
Leavenworth, Kansas

M. W. Watson
Pres., M. W. Watson Co.
Topeka, Kansas

Daniel Webster
Marc Eidlitz & Son
New York, N. Y.

David J. White
Treas., Bay State Dredging & Constr. Co.
East Boston, Mass.

STAFF

Edw. J. Harding
Managing Director

H. E. Foreman
Assistant Managing Director

E. J. Brosnan
C. S. Embrey
J. D. Marshall

H. J. Kirk
W. A. Snow
R. D. Winstead
Constructor

AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS

GENERAL OFFICES: 1222-24 National Press Building, Washington, D. C.

An Association composed of the State Highway Department Officials of the forty-eight states, Hawaiian Islands and the United States Bureau of Public Roads.

EXECUTIVE OFFICERS

PRESIDENT
O. S. Warden
Great Falls, Montana

SECRETARY
W. C. Markham
Washington, D. C.

TREASURER
W. W. Mack
Dover, Delaware

VICE-PRESIDENTS

G. H. Henderson
First District
Providence, Rhode Island

E. D. Kenna
Second District
Jackson, Mississippi

H. C. Frahm
Third District
Bismarck, North Dakota

T. S. O'Connell
Fourth District
Phoenix, Arizona

EXECUTIVE COMMITTEE

A. W. Brandt
New York

J. A. MacDonald
Connecticut

Samuel Eckels
Pennsylvania

H. G. Shirley
Virginia

W. V. Buck
Kansas

C. H. Moorefield
South Carolina

Gibb Gilchrist
Texas

F. R. White
Iowa

T. H. Cutler
Missouri

C. H. Purcell
California

T. H. MacDonald
Bureau of Public Roads
Washington, D. C.

PURPOSE—The purpose for which the Association is organized and for which it shall be perpetuated is to study the various materials, methods of construction and maintenance, all problems connected with highway transport, and other highway problems of the United States; to exchange ideas; to promote a closer relationship between State and Territorial Highway Departments with a view of establishing a uniform system of administration, construction and maintenance; to promote legislation for the purpose of conserving the capital invested in highway construction and maintenance by producing the highest possible efficiency; and to cooperate in every way possible with the United State Bureau of Public Roads or similar Federal organizations in the consideration of road problems.

The Association, recognizing that the financing, building, maintenance, operation and administration of adequate highways are an integral part and one of the major factors in the development of the science of modern highway transport; it is, therefore, the policy of the Association that it dedicate one of its major activities to the development of technical administration and highway operation standards and policies, and further:

That the constituent bodies—the individual State Highway Departments and the Bureau of Public Roads of the United States—Pledge themselves individually and collectively to the making available of their scientific experts on the necessary committees to develop these policies and standards.

MEMBERSHIP—The membership of this Association shall be active, associate and honorary members.

ACTIVE MEMBERS shall be the highway commissioners and chief engineers and their chief directing officials actively engaged in the administrative work of the various highway departments of the different States, Territories and of the Bureau of Public Roads and of the Provinces of the Dominion of Canada and of the Dominion of Canada, who shall pay their annual dues. The voting shall be by States, Territories and Provinces and each State department, each Territory and each Province, and the Federal Bureau of Public Roads and the Dominion of Canada shall each be entitled to one vote, which vote shall be cast by the representatives of the department present. Upon matters of legislation the vote shall be cast by the representative of the department present, and in case a majority of the qualified active members do not have a representative present, a letter ballot shall be sent to the departments not represented.

ASSOCIATE MEMBERS shall be the chief directing officials, actively engaged in the administrative work of the Highway Department of the Republic of Mexico or any of its States, and such assistant and deputy commissioners, assistant and resident engineers, and chief directing officials in the highway departments of North American countries, their States and Provinces as are not chief directing officials actively engaged in the administrative work of their highway department, who are recommended by an active member and who shall pay annual dues. An associate member shall have the privilege of taking part in the discussions, but shall not have the right to vote.

HONORARY MEMBERS of this Association shall be composed of former State and Territorial Highway officials and the professors of highway engineering in accredited universities. Active members who cease to be eligble as such shall become honorary members, and other honorary members shall be proposed by a member and elected by the Executive Committee. Honorary members shall be entitled to participate in discussions, but shall not have the privilege of voting upon any subject.

OFFICERS—The officers of this Association shall be selected from the active highway officials of the different State Highway Departments. No two officers shall be selected from the same

State. The officers shall be President, four Vice-Presidents and Treasurer, who shall be elected by ballot at the annual meeting of the Association, to hold office for one year and until their successors have been elected and qualified, and also an Executive Secretary who shall be selected by and serve under the authority of the Executive Committee. There shall be an Executive Committee of eleven members, ten of whom shall be elected by ballot from the membership of the Association at the annual meeting of the Association. At the first election two members of the Executive Committee shall be selected for one year, two for two years, two for three years, two for four years and two for five years, and thereafter two members at each annual meeting for a term of five years. The President upon retiring from office shall be a member of the Executive Committee for one year. All vacancies in this Committee may be filled for the unexpired term. No two members of the Executive Committee shall be from the same State. The President shall be ex-officio a member of the Executive Committee and shall be a Chairman thereof.

STANDING AND SPECIAL COMMITTEES—The By-Laws provide that there shall be a Committee on Administration and a Committee on Standards, together with such sub-committees as from time to time it may be deemed necessary. Special committees may be organized who may work with the committee of other organizations interested in highway work, which committees when organized shall have authority to subdivide the work according to their own plans.

In general, these committees shall cover the following subjects:

ADMINISTRATION—Whose investigations and deductions shall cover general highway department administrative duties including the problems of highway financing, uniform accounting, uniform highway laws and traffic control and safety.

STANDARDS—To include road construction, bridge construction, tests and investigation of materials, maintenance, all phases of highway research; with sub-committee assignments whose work, including specifications, surveys, plans, design, tests, equipment, etc., shall be co-ordinated by the general committee on standards.

SPECIAL COMMITTEES—These committees shall be organized for assignments of a special character, such as Highway Transport, Highway Education, Highway Research with other organizations, American Engineering Standards, etc.

STANDING AND OTHER COMMITTEES

COMMITTEE ON ADMINISTRATION

J. D. Adams
Indiana

T. Warren Allen
Bureau of Public Roads

H. N. Arnold
Oklahoma

E. L. Bailey
West Virginia

Fred Balzer
Nevada

A. W. Brandt
New York

Frank Butt
New Mexico

J. S. Cargile
Arkansas

T. H. Cutler
Missouri

Harry Darby
Kansas

S. G. Dowell
Arizona

N. W. Elsberg
Minnesota

W. R. Ely
Texas

F. E. Everett
New Hampshire

A. F. Foran
New Jersey

C. O. Hearon
South Carolina

H. A. Hopkins
California

E. B. Jeffress
North Carolina

E. D. Kenna
Mississippi

Robert Kingery
Illinois

S. S. Lewis
Pennsylvania

J. A. MacDonald
Connecticut

O. W. Merrell
Ohio

W. E. O'Brien
Wisconsin

H. E. Sargent
Vermont

L. G. Smith
Alabama

C. B. Treadway
Florida

G. Clinton Uhl
Maryland

Chas. D. Vail
Colorado

M. D. Van Wagoner
Michigan

O. S. Warden
Montana

E. W. Webster
Tennessee

F. R. White
Iowa

SUB-COMMITTEE ON UNIFORM ACCOUNTING
C. G. Clark, Bureau of Public Roads, Chairman

COMMITTEE ON STANDARDS
E. W. James, Chief, Division of Design, Bureau of Public Roads, Washington, D. C., General Chairman

COMMITTEE ON BRIDGES AND STRUCTURES
A. L. Gemeny, Bureau of Public Roads, Washington, D. C., Chairman

COMMITTEE ON HIGHWAY RESEARCH ACTIVITIES
V. L. Glover, Engineer of Materials, Illinois Division of Highways, Chairman

COMMITTEE ON HIGHWAY TRANSPORT
Thomas H. MacDonald, Chief, Bureau of Public Roads, Washington, D. C., Chairman

COMMITTEE ON MATERIALS
H. S. Mattimore, Engineer of Tests, Pennsylvania Department of Highways, Chairman

COMMITTEE ON ROAD DESIGN
O. L. Kipp, Construction Engineer, Minnesota State Highway Department, Chairman

COMMITTEE ON ROAD CONSTRUCTION
Charles H. Moorfield, State Highway Engineer, South Carolina State Highway Department, Chairman

COMMITTEE ON MAINTENANCE
C. S. Mullen, Chief Engineer, Virginia State Highway Department, Chairman

COMMITTEE ON COOPERATION WITH CONTRACTORS
Samuel Eckels, Chief Engineer, Pennsylvania Department of Highways, Chairman

COMMITTEE ON INTERNATIONAL HIGHWAY RELATIONS
W. R. Ely, Chairman State Highway Commission, Texas, Chairman

COMMITTEE ON ROADSIDE BEAUTIFICATION
Luther M. Keith, State Highway Tree Warden, State Highway Commission, Connecticut, Chairman

BUREAU OF PUBLIC ROADS
UNITED STATES DEPARTMENT OF AGRICULTURE

WILLARD BUILDING, WASHINGTON, D. C.

BUREAU STAFF

Thos. H. MacDonald, Chief
Capt. P. St. J. Wilson, Chief Engineer
Dr. L. I. Hewes, Deputy Chief Engineer, San Francisco, Calif.
R. E. Toms, Chief, Division of Design.
H. K. Bishop, Chief, Division of Construction
C. D. Curtiss, Chief, Division of Control
H. S. Fairbank, Chief, Division of Information
E. W. James, Chief, Division of Highway Transport
T. W. Allen, Chief, Division of Management
E. F. Kelley, Chief, Division of Tests
L. E. Boykin, Chief, Division of Laws and Contracts
O. L. Grover, Bridge Engineer
H. J. Spelman, Eastern Parks

DISTRICT OFFICES AND REPRESENTATIVES

Regional Office, Districts 1, 2, 3, 11 and 12. Dr. L. I. Hewes, Deputy Chief Engineer, Mark Sheldon Building, 461 Market Street, San Francisco, Calif.

District No. 1. Oregon, Washington and Montana. W. H. Lynch, Box 3900, Portland, Ore.

District No. 2. California, Arizona, Nevada and Territory of Hawaii. C. H. Sweetser, Mark Sheldon Bldg., 461 Market Street, San Francisco, Calif.

District No. 3. Colorado, New Mexico and Wyoming. J. A. Elliott, 237 Customhouse Bldg., Denver, Colo.

District No. 4. Minnesota, North Dakota, South Dakota and Wisconsin. A. E. Palen, 410 Hamm Bldg., St. Paul, Minn.

District No. 5. Iowa, Kansas, Missouri and Nebraska. Clifford Shoemaker, Saunders-Kennedy Bldg., Omaha, Nebr.

District No. 6. Arkansas, Louisiana, Oklahoma and Texas. C. E. Swain, Old Post Office Bldg., Fort Worth, Texas.

District No. 7. Illinois, Indiana, Kentucky and Michigan. J. T. Voshell, Bureau of Public Roads, South Chicago P. O. Bldg., Chicago, Ill.

District No. 8. Alabama, Georgia, Florida, Mississippi, South Carolina and Tennessee. C. D. Snead, Box 60, Montgomery, Ala.

District No. 9. Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont. A. G. Bruce, Federal Bldg., Troy, N. Y.

District No. 10. Delaware, Maryland, North Carolina, Ohio, Pennsylvania, Virginia and West Virginia. V. M. Peirce, Bureau of Public Roads, Washington, D. C.

District No. 11. Alaska. M. D. Williams, Juneau, Alaska.

District No. 12. Idaho and Utah. B. J. Finch, Box 391, Ogden, Utah.

ACTIVITIES

The Bureau of Public Roads, in coöperation with the several State Highway Departments, is responsible for the construction of all Federal-aid roads. The Bureau also supervises the expenditure of Federal emergency highway funds, and the construction of roads in the National forests, on public lands, in public parks and Indian reservations in coöperation with other Government bureaus. It is a principal contributor to the advancement of scientific knowledge in the design, construction and maintenance of roads, and it also conducts investigations in traffic conditions and economic matters to determine the value of roads and the services they render.

Supplementing this work, the Bureau of Public Roads is supervising the construction of public works highways under the National Industrial Recovery Act. Under this Act, an appropriation of $400,000,000 was made by Congress in 1933 for road building with a view to reducing unemployment through road construction.

FEDERAL-AID ROADS

The Federal-aid highway system, consisting of interstate and intercounty highways, was designated jointly by the several State Highway Departments and the Secretary of Agriculture in accordance with the Federal Highway Act of 1921. Every section of highway included in this system, which included 206,277 miles on June 30, 1933, is eligible for improvement with Federal aid.

The appropriations under the Federal highway act are apportioned among the 48 States and Hawaii on the basis of the area, population and mileage of post roads in each of the States. In general, the money thus apportioned may be used under the supervision of the State Highway Departments with the approval of the Bureau of Public Roads and the Secretary of Agriculture for the improvement of sections of the designated system to the limit of 50 per cent of the cost of the improvement, or not more than $15,000 per mile, except in the case of bridges.

PUBLIC WORKS HIGHWAYS

The regular Federal-aid procedure was modified by the National Industrial Recovery Act for the construction of public works highways. Federal grants of money do not have to be matched by funds from the States. In addition to roads built on the regular Federal-aid system (not more than 50 per cent of the funds), provision is made for the extension of Federal-aid system roads through municipalities (not less than 25 per cent of the funds), and for the construction of secondary or feeder roads (not more than 25 per cent of the funds). The appropriation of funds to the States is seven-eighths in accordance with the Federal Highway Act of 1921 and one-eighth according to population. Appropriated funds may be used also to match regular Federal-aid appropriations. Maintenance of public works roads included in the Federal-aid system is an obligation of the States; in the case of municipal extensions of the system and secondary or feeder roads, the maintenance responsibility may by agreement be transferred to the appropriate municipal or county authority.

NATIONAL FOREST ROADS

The appropriations for Federal forest road construction are expended in the States in which the national forests are located on specifically designated systems of forest highways.

NATIONAL PARKS ROADS

Through a coöperative agreement the Bureau of Public Roads has assumed charge for the Office of National Parks, Buildings and Reservations, U. S. Department of the Interior, of the location and construction of major roads in the national parks. Work of this character has already been completed or is in progress in the national parks.

RESEARCH

The tests and experiments made by the Bureau at its station at Arlington, Virginia, have attracted wide attention throughout the United States and in foreign countries. Among the outstanding contributions to highway engineering are the Bureau's measurements of the amount and effect of motor truck impact, and its studies of surface wear of pavements, traffic on the roads, the characteristics of subgrade soils, and other similar physical and economic investigations.

Federal, State and County
HIGHWAY DEPARTMENT LIST

Officially Revised to May 1, 1933

BUREAU OF PUBLIC ROADS
U. S. DEPARTMENT OF AGRICULTURE
Willard Building
Washington, D. C.

BUREAU STAFF

Thos. H. McDonald, Chief....Washington
Capt. P. St. J. Wilson, Chief Engr....Washington
Dr. L. I. Hewes, Deputy Chief Engr....San Francisco, Cal.
H. K. Bishop, Chief of Construction....Washington
R. E. Toms, Chief, Div. of Design....Washington
C. D. Curtis, Div. of Control....Washington
H. S. Fairbank, Chief, Div. of Information....Washington
T. W. Allen, Chief, Div. of Management....Washington
E. W. James, Chief Div. of Highway Trans....Washington
E. F. Kelley, Chief, Div. of Tests....Washington
L. E. Boykin, Chief, Div. of Laws and Contracts ....Washington
O. L. Grover, Bridge Engr....Washington
H. J. Spelman, Eastern Parks....Washington

DISTRICT REPRESENTATIVES

C. D. Snead, Box 60....Montgomery, Ala.
C. H. Sweetser, Mark Sheldon Bldg., 461 Market St. ....San Francisco, Cal.
J. A. Elliott, 237 Customhouse Bldg....Denver, Colo.
V. M. Pierce, Willard Bldg....Washington
J. T. Voshell, South Chicago P. O. Bldg....Chicago, Ill.
A. E. Palen, 410 Hamm Bldg....St. Paul, Minn.
Clifford Shoemaker, Saunders-Kennedy Bldg..Omaha, Neb.
A. G. Bruce, Federal Bldg....Troy, N. Y.
W. H. Lynch, Box 3900....Portland, Ore.
C. E. Swain, Old Post Office Bldg....Fort Worth, Tex.
B. J. Finch, Box 391....Ogden, Utah
M. D. Williams....Juneau, Alaska

ALABAMA
STATE HIGHWAY DEPARTMENT
Montgomery

COMMISSION

L. G. Smith, Director of Highways....Montgomery
S. L. Hood, Auditor....Montgomery
F. O. McManus, Chief Clerk....Montgomery

ENGINEERS

R. D. Jordan, Supt. of Maint....Montgomery
L. M. Dinsmore, Office Engr....Montgomery
H. H. Houk, Bridge Engr....Montgomery
J. L. Land, Testing Engr....Montgomery

DIVISION ENGINEERS

S. J. Cummings....Montgomery
C. J. Sherlock....Montgomery
H. D. Barnum....Decatur
Wm. Herzberg....Birmingham

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Autauga	G. W. Pickett, County Surveyor	Montgomery
Baldwin	Marvin Taylor, County Engineer	Bay Minette
Barbour	G. B. Espey, County Engineer	Eufaula
Bullock	C. K. Dunbar, Resident Engineer, State Highway Department	Union Springs
Calhoun	H. B. Blackwell, County Engineer and Surveyor	Anniston
Chambers	O. Lamb, County Engineer and Surveyor	Lafayette
Cherokee	M. W. Pharis, County Highway Commissioner	Center
Choctaw	C. F. Britt, County Supt	Robjohn
Clarke	W. G. Kennedy, County Engineer	Grove Hill
Colbert	Joe Flippen, City Engineer and County Surveyor	Tuscumbia
Cullman	J. A. N. Smith, County Surveyor	Cullman
Dallas	D. G. Wilkinson, County Engineer	Selma
Franklin	I. T. Jackson, County Engineer	Russellville
Greene	J. T. McLemore, County Engineer	Eutaw
Hale	R. A. Langworthy, County Engineer	Greensboro
Henry	M. B. Clark, County Commissioner	Abbeville
Houston	Will Crawford, County Surveyor	Dothan
Jackson	J. C. Wall, County Surveyor	Hollywood
Jefferson	C. J. Rogers, County Engineer	Birmingham
Lauderdale	H. L. Gross, County Engineer	Florence
Lawrence	Ben Masterson, County Surveyor	Moulton
Lee	S. E. Fitch, County Engineer	Opelika
Marshall	W. C. Goodwin, County Surveyor	Guntersville
Mobile	J. B. Converse, County Engineer	Mobile
Montgomery	Thomas H. Edwards, County Engineer	Montgomery
Morgan	M. S. Bingham, County Engineer	Decatur
Perry	C. B. Lockhart, County Engineer	Marion
Pickens	W. M. Meredith, County Engineer	Carrollton
Pike	J. C. Cotton, County Superintendent	Troy
Russell	S. E. Fitch, County Engineer	Seale
St. Clair	G. W. Robertson, County Surveyor	Pell City
Talladega	J. M. Caldwell, County Engineer	Talladega
Tallapoosa	Walter Strother, County Engineer	Dadeville
Walker	C. B. Stalnaker, County Engineer	Jasper

ARIZONA
STATE HIGHWAY COMMISSION
Phoenix

COMMISSION

Shelton G. Dowell, Chairman....Douglas
Ray N. Vyne, Vice-Chairman....Prescott
Jacob Barth....St. Johns
Monte Mansfield....Tucson
C. E. Addams....Phoenix
C. C. Jarrett, Secretary....Phoenix

DEPARTMENT STAFF

T. S. O'Connell, State Highway Engineer....Phoenix
Sid Smyth, Deputy State Highway Engineer....Phoenix
J. W. Powers, Materials and Resident Engineer...Phoenix
W. F. Frerichs, Purchasing Agent....Phoenix
R. A. Hoffman, Bridge Engineer....Phoenix
H. C. Hatcher, Statistical Engineer....Phoenix
E. V. Miller, Engineer of Plans....Phoenix
J. S. Mills, Engineer of Estimates....Phoenix

DISTRICT ENGINEERS

Geo. B. Shaffer, District Engineer....Phoenix
F. N. Grant, District Engineer....Phoenix
W. R. Hutchins, District Engineer....Phoenix
R. C. Perkins, District Engineer....Phoenix

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Apache	Parley J. Heap, County Engineer	St. Johns
Cochise	Roger Pelton, County Engineer	Bisbee
Coconino	J. B. Wright, County Engineer	Flagstaff
Gila	Oscar T. Lyon, Road Foreman	Globe
Greenlee	A. J. Kerr, County Engineer	Clifton
Maricopa	Barney R. Hodgin, County Engineer	Phoenix
Mohave	E. Ross, Householder, County Engineer	Kingman

Navajo—K. L. Hudson, County Engineer.....Holbrook
Pima—Frank B. Kendall.....Tucson
Pinal—L. O. Fiscal, County Engineer.....Florence
Santa Cruz—W. H. Roper, County Engineer.....Nogales
Yavapai—R. L. Merritt, County Engineer.....Prescott
Yuma—W. L. Ellison.....Yuma

ARKANSAS
DEPARTMENT HIGHWAYS AND IMPROVEMENTS
Little Rock

COMMISSIONERS

J. S. Cargile, Chairman.....Arkadelphia
Dave Block .....Wynne
Ben B. Johnston.....Fort Smith
L. A. Black.....DeWitt
C. H. Murphy.....El Dorado

DEPARTMENT STAFF

Jas. R. Rhyne, Director of Highways.....Little Rock
W. W. Zass, Chief Engineer.....Little Rock
N. B. Garver, Bridge Engineer.....Little Rock
L. E. Lumpkin, Testing Engineer.....Little Rock
J. A. Francis, Supervisor of Equipment.....Little Rock
O. L. Hemphill, Construction Engineer.....Little Rock

DISTRICT SUPERVISORS

John E. Buxton.....Wynne
F. H. Neely.....Pine Bluff
Frank Burnside .....Hope
J. D. Winder.....Fort Smith
J. C. Baker.....Paragould
J. F. Mayne.....Little Rock
F. A. Humphreys.....Harrison

COUNTY HIGHWAY OFFICIALS

County. Official. City.

Arkansas—F. M. Quertermons, County Surveyor...DeWitt
Ashley—B. B. Horton, County Surveyor.....Hamburg
Baxter—J. E. Goforth, County Surveyor...Mountain Home
Benton—Wilson Brown, County Surveyor.....Bentonville
Boone—T. M. Jones, County Surveyor.....Harrison
Bradley—C. T. Beard, County Surveyor.....Warren
Calhoun—J. R. Sellers, County Surveyor.....Hampton
Carroll—G. M. Whitley, County Engineer.....Berryville
Chicot—Ray Gilliam, County Surveyor.....Lake Village
Clark—Frank Koresky, County Surveyor.....Arkadelphia
Cleburne—A. G. Pettit, County Surveyor....Heber Springs
Cleveland—M. W. Wilson, County Surveyor.....Rison
Columbia—W. M. Young, County Surveyor.....Magnolia
Conway—S. G. Davies, County Surveyor.....Morrillton
Crawford—E. E. Turner, County Surveyor.....Van Buren
Dallas—T. L. Oakley, County Surveyor.....Fordyce
Desha—Geo. W. Reese, County Surveyor....Arkansas City
Franklin—E. S. Turner, County Surveyor.....Ozark
Grant—M. N. McDonald, County Engineer.....Sheridan
Greene—R. E. L. Strickland, County Surveyor...Paragould
Hot Springs—W. M. Morrison, County Surveyor..Malvern
Independence—I. S. Henley, County Surveyor...Batesville
Izard—Mack Cypert, County Surveyor.....Melbourne
Jackson—W. A. Bowman, County Engineer and Surveyor .....Newport
Jefferson—C. P. Gould, County Surveyor.....Pine Bluff
Johnson—Ezra Adkins, County Surveyor.....Clarksville
Lawrence—Fred Sloan .....Powhatan
Lee—Allen Robinson, County Surveyor.....Marianna
Little River—A. S. Fellows, County Surveyor...Ashdown
Logan—R. A. Sadler, County Surveyor.....Paris
Marion—J. A. Smith, County Surveyor.....Yelville
Miller—B. E. Oats.....Texarkana
Mississippi—B. N. Wilson.....Osceola
Montgomery—Walter Hickox, County Judge....Mount Ida
Nevada—Hugh White, County Surveyor.....Prescott
Ouachita—A. J. Perry, County Surveyor.....Camden
Phillips—T. H. Jacks.....Helena
Pike—N. T. Hendron, County Surveyor.....Murfreesboro
Poinsett—John E. Buxton, County Surveyor....Harrisburg
Polk—A. W. Wear, County Judge.....Mena
Pope—Warren Williamson, County Surveyor...Russellville
Prairie—Wm. Radican, County Surveyor.....Des Arcs
Pulaski—Henry Conway, County Surveyor.....Little Rock
Randolph—Cecil Eaton, County Surveyor.....Pocahontas
Saline—B. F. Henry, County Surveyor.....Benton
Scott—M. R. Cruse, County Surveyor.....Waldron
Searcy—A C. Hamm, County Surveyor.....Marshall
Sevier—E. S. Byington, Civil Engineer.....DeQueen
Sharp—Ray Murphy, County Surveyor.....Evening Shade
Stone—Hugh R. Moore, County Surveyor..Mountain View
Union—J. T. Kinard, County Surveyor.....El Dorado
Van Buren—J. E. Wright, County Surveyor.....Clinton
Washington—A. W. Shreve, County Surveyor..Fayetteville
White—M. S. Cook, County Surveyor.....Searcy
Woodruff—L. G. Frey, County Surveyor.....Augusta
Yell—Grant Harding, County Surveyor.....Danville

CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
Highway Building
Sacramento

COMMISSION

Harry A. Hopkins, Chairman.....Taft
T. A. Reardon, State Building.....San Francisco
Frank Tetley .....Riverside
Philip A. Stanton.....Anaheim
Dr. W. W. Barham.....Yreka

DEPARTMENT STAFF

C. H. Purcell, State Highway Engineer, P. O. Box 1499 .....Sacramento
G. T. McCoy, Principal Assistant Engineer, P. O. Box 1499 .....Sacramento
Fred J. Grumm, Engineer of Surveys and Plans, P. O. Box 1499.....Sacramento
Chas. S. Pope, Construction Engineer, P. O. Box 1499 .....Sacramento
T. W. Dennis, Maintenance Engineer, P. O. Box 1499 .....Sacramento
R. H. Stalnaker, Supervisor of Equipment, P. O. Box 1499 .....Sacramento
T. E. Stanton, Materials and Resident Engineer, P. O. Box 1499.....Sacramento
E. R. Higgins, Comptroller, P. O. Box 1499....Sacramento
F. W. Panhorst, Bridge Engineer, P. O. Box 1499 .....Sacramento
C. H. Thorpe, Purchasing Agent, P. O. Box 1499 .....Sacramento
R. H. Wilson, Office Engineer, P. O. Box 1499.Sacramento

DISTRICT ENGINEERS

J. W. Vickrey, District Engineer No. 1.....Eureka
F. W. Haselwood, District Engineer No. 2.....Redding
C. H. Whitmore, District Engineer No. 3, Hotel Marysville .....Marysville
J. H. Skeggs, District Engineer No. 4, State Building .....San Francisco
L. H. Gibson, District Engineer No. 5.....San Luis Obispo
R. M. Gillis, District Engineer No. 6.....Fresno
S. V. Cortelyou, District Engineer No. 7—808 California State Office Building.....Los Angeles
E. Q. Sullivan, District Engineer No. 8.....San Bernardino
S. W. Lowden, District Engineer No. 9.....Bishop
R. E. Pierce, District Engineer No. 10—47 No. Grant St. .....Stockton
E. E. Wallace, District Engineer No. 11, Union Building .....San Diego

COUNTY HIGHWAY OFFICIALS

County. Official. City.

Alameda—Burnett Hamilton, County Surveyor....Oakland
Amador—W. E. Downs, County Surveyor.....Jackson
Butte—J. A. Bumgarner.....Oroville
Calaveras—W. S. Coulter, County Engineer and Surveyor .....San Andreas
Colusa—John N. Boles.....Colusa
Contra-Costa—R. R. Arnold, County Surveyor....Martinez
Del Norte—H. M. Malphais, County Surveyor.Crescent City
Eldorado—Henry Lahiff, County Engineer and Surveyor .....Placerville
Fresno—Chris. P. Jensen, County Surveyor.....Fresno
Glenn—A. J. Hoever, County Engineer.....Willows
Humboldt—Frank E. Kelly, County Surveyor.....Eureka
Imperial—Henry Burke, County Engineer and Surveyor .....ElCentro
Inyo—B. E. Sherwin, County Surveyor.....Independence
Kern—J. R. Thornton, County Surveyor.....Bakersfield
Kings—Roy May, County Engineer and Surveyor.Hanford
Lake—Fred S. Wilson, County Surveyor.....Lakeport

Lassen—M. J. Tilley, County Surveyor.....Susanville
Los Angeles—J. E. Rockhold, County Surveyor.Los Angeles
Madera— K. L. Hughes, County Surveyor.....Madera
Marin—Rodney E. Messner, County Surveyor...San Rafael
Mariposa—F. A. Casccia, County Surveyor.....Mariposa
Mendocino—E. H. Smith.....Ukiah
Merced—W. E. Bedesen, County Surveyor.....Merced
Modoc—Geo. T. Cline, County Surveyor.....Alturas
Mono—Arthur J. Warrington, County Surveyor.Bridgeport
Monterey—Howard F. Cozzens, County Surveyor..Salinas
Napa—Thos. Townsend, County Surveyor.....Napa
Nevada—J. F. O'Connor, County Surveyor....Nevada City
Orange—W. K. Hillyard, County Surveyor (Nat H. Neff, County Engineer).....Santa Ana
Placer—J. A. Shields, County Surveyor.....Auburn
Plumas—A. J. Watson, County Surveyor.....Quincy
Riverside—A. C. Fulmore, County Surveyor.....Riverside
Sacramento—Chas. W. Deterding, Jr., County Engineer.....Sacramento
San Benito—Alfred M. McCary, County Surveyor.Hollister
San Bernardino—H. L. Way, County Surveyor.....San Bernardino
San Diego—Ernest R. Childs, County Surveyor..San Diego
San Francisco—M. M. O'Shaughnessy.....San Francisco
San Joaquin—Julius B. Manthey, County Engineer and Surveyor.....Stockton
San Luis Obispo—John P. Black, County Surveyor.....San Luis Obispo
San Mateo—James S. James, County Surveyor.....Redwood City
Santa Barbara—Owen H. O'Neill, County Surveyor.....Santa Barbara
Santa Clara—R. B. Chandler, County Engineer and Surveyor.....San Jose
Santa Cruz—Lloyd Bowman, County Surveyor..Santa Cruz
Shasta—C. R. Wiegel, County Surveyor.....Redding
Sierra—Geo. F. Taylor, County Surveyor.....Downieville
Siskiyou—Albert F. Parrott.....Yreka
Solano—F. A. Steiger, County Engineer and Surveyor.....Fairfield
Sonoma—E. A. Peugh.....Santa Rosa
Stanislaus—Geo. D. Macomber, County Surveyor..Modesto
Sutter—Wm. Shearer, County Surveyor.....Yuba City
Tehama—W. F. Luning, County Engineer and Surveyor.....Red Bluff
Trinity—T. J. Montgomery, County Surveyor..Weaverville
Tulare—T. W. Switzer, County Surveyor.....Visalia
Tuolumne—Robt. D. Strauch, County Engineer....Sonora
Ventura—Chas. W. Petit, County Surveyor.....Ventura
Yolo—John L. Lynde, County Surveyor.....Woodland
Yuba—Jason R. Meek, County Surveyor.....Marysville

COLORADO
STATE HIGHWAY DEPARTMENT
Denver

DEPARTMENT STAFF

Peter Seerie, Chairman, Highway Advisory Board, Interstate Trust Building.....Denver
Chas. D. Vail, State Highway Engineer.....Denver
Oliver T. Reedy, State Assistant Engineer.....Denver
J. E. Maloney, Assistant Engineer.....Denver
Paul Bailey, Bridge Engineer.....Denver
J. P. Donovan, Maintenance Engineer.....Denver
Ira R. Taylor, State Purchasing Agent.....Denver

ADVISORY BOARD

Wm. Weiser, 2nd District.....Grand Junction
I. F. Beauchamp, 3rd District.....Trinidad
W. T. Mathis, 4th District.....Pueblo
J. Hayes-Davis, 5th District.....Colorado Springs
L. C. Moore, 6th District.....Fort Collins
Frank H. Blair, 7th District.....Sterling

DIVISION ENGINEERS

E. E. Montgomery, Division No. 1.....Denver
J. J. Vandemoer, Division No. 2.....Grand Junction
J. R. Cheney, Division No. 3.....Durango
James D. Bell, Division No. 4.....Pueblo
Ernest Montgomery, Division No. 5.....Colorado Springs
H. L. Jenness, Division No. 6.....Glenwood Springs
A. B. Collins, Division No. 7.....Greeley

COUNTY HIGHWAY OFFICIALS

County. Official. City.
Adams—Peter O'Brian, County Surveyor.....Brighton
Alamosa—Mark U. Watrous.....Alamosa
Arapahoe—S. L. Stewart, County Surveyor.....Littleton
Archuleta—Robt. A. Howe, County Engineer and Surveyor.....Pagosa Springs
Baca—No County Surveyor.....Springfield
Bent—Sydney Flynn, County Surveyor.....Las Animas
Boulder—Fred A. Fair, County Surveyor.....Boulder
Chaffee—Howard Sneddon, County Surveyor..Buena Vista
Cheyenne—D. H. Zuck, County Surveyor..Cheyenne Wells
Clear Creek—C. L. Harrington, County Surveyor.....Georgetown
Conejos—J. F. Thomas, County Surveyor.....Conejos
Costilla—A. H. Martin, County Surveyor.....San Luis
Crowley—J. Logan Tucker.....Ordway
Custer—Frank Wagner, County Engineer.....Silver Cliff
Delta—H. D. Graham, County Engineer and Surveyor.....Delta
Denver—Albion K. Vickery, County and City Engineer.....Denver
Dolores—Geo. N. Herron, Jr., County Surveyor.....Rico
Douglas—H. H. Curtis, County Surveyor.....Castle Rock
Eagle—Carl I. Dismant, County Surveyor.....Eagle
Elbert—D. M. Sultz, County Surveyor.....Kiowa
El Paso—R. M. Cannon.....Colorado Springs
Fremont—L. D. Miller, Surveyor.....Canon City
Garfield—W. H. Trumbler, County Surv.Glenwood Springs
Gilpin—Harry L. Barr.....Central City
Grand—Roy Polhamus, County Surveyor.....Hot Sulphur Springs
Gunnison—Jack Robinson, County Engineer.....Gunnison
Hinsdale—Chas. Harkness, County Engineer.....Lake City
Huerfano—A. S. Wilburn, County Surveyor...Walsenburg
Jackson—A. B. Mackenzie, Surveyor.....Walden
Jefferson—Harold W. Gardner, County Surveyor...Golden
Kiowa—No County Surveyor.....Eads
Kit Carson—Ira B. Rowbotham, County Engr...Burlington
Lake—Fred J. McNair, County Surveyor.....Leadville
LaPlata—A. L. Kroeger, County Engineer.....Durango
Larimer—James H. Andrews, County Engineer and Surveyor.....Fort Collins
Las Animas—Earl T. Lindsay, County Surveyor...Trinidad
Lincoln—No County Surveyor.....Hugo
Logan—E. J. Youngquist, County Engineer.....Sterling
Mesa—F. C. Merrell, County Surveyor.....Grand Junction
Mineral—D. C. LaFont, County Engineer and Surveyor.....Creede
Moffat—L. J. Dolan, County Engineer.....Craig
Montezuma—H. L. Owens, County Surveyor.....Cortez
Montrose—J. E. McDaniel, County Surveyor.....Montrose
Morgan—No County Surveyor.....Fort Morgan
Otero—Vincent Guthrie, County Surveyor.....La Junta
Ouray—Geo. R. Hurlburt, County Engineer and Surveyor.....Ouray
Park—G. F. Galloway, County Surveyor.....Fair Play
Phillips—C. A. Guernsey, County Surveyor.....Holyoke
Pitkin—Frank Willoughby, County Surveyor.....Aspen
Prowers—Geo. H. Russell, County Engineer.....Lemar
Pueblo—H. C. Wetmore, County Surveyor.....Pueblo
Rio Blanco—Maurice Ruckman.....Meeker
Rio Grande—Glenn O. Cochran, Road Superv....Del Norte
Routt—Stanley Dismuke, County Eng...Steamboat Springs
Saguache—Raymond Johnson, County Surveyor..Saguache
San Juan—A. W. Harrison, County Surveyor.....Silverton
San Miguel—B. W. Purdy, County Surveyor.....Telluride
Sedgwick—C. M. Slusser, County Engineer.....Julesburg
Summit—Ralph C. Black, County Surveyor..Breckenbridge
Teller—T. H. Evans Jones, County Surveyor.Cripple Creek
Washington—No County Surveyor.....Akron
Weld—L. L. Stimson, County Engineer.....Greeley
Yuma—Grant Woodward, County Engineer.....Wray

CONNECTICUT
STATE HIGHWAY DEPARTMENT
Hartford

DEPARTMENT STAFF

John A. MacDonald, Commr. State Off. Bldg.....Hartford
Elmer C. Weldon, Deputy Commr. St. Off. Bldg..Hartford
C. G. Nichols, Exec. Deputy Commr. St. Off. Bldg.Hartford
Geo. E. Hamlin, Maint. Engr. St. Off. Bldg.....Hartford
L. G. Sumner, Bridge Engr. St. Off. Bldg.....Hartford
C. F. Taylor, Engr. of Rights of Way St. Off. Bldg.Hartford

RESIDENT ENGINEERS

O. G. Beyer, Purchas. Agent St. Off. Bldg.....Hartford
J. E. Vehring, Supt. of Prop. St. Off. Bldg.....Hartford

John Smith, Engr. of Location and Des. St. Off. Bldg. ....Hartford
A. W. Bushell, Construction Eng. St. Off. Bldg...Hartford
W. H. Sharp, Engr. of Highway Control St. Off. Bldg. ....Hartford

MAINTENANCE DISTRICT SUPERVISORS

N. W. Benedict, Maint. Dis. Supv. St. Off. Bldg...Norwalk
F. W. Nolan, Maint. Dis. Supv. St. Off. Bldg..New Milford
A. Louis Kalas, Maint. Dis. Supv. St. Off. Bldg..Naugatuck
H. C. Carsten, Maint. Dis. Supv. St. Off. Bldg....Branford
W. A. Spencer, Maint. Dis. Supv. St. Off. Bldg..Deep River
B. B. Green, Maint. Dis. Supv. St. Off. Bldg.....Norwich
N. W. Hardenbergh, Maint. Dis. Supt. St. Off. Bldg.Canaan
J. Deming, Maint. Dis. Supv. St. Off. Bldg.....Newington
O. F. Hemmeler, Maint. Dis. Supv. St. Off. Bldg. ....West Willington
J. W. Maher, Maint. Dis. Supv. St. Off. Bldg.....Putnam
L. J. Francis, Maint. Dis. Supv. St. Off. Bldg. ....Windsor Locks

DELAWARE
STATE HIGHWAY DEPARTMENT
Dover

OFFICIALS AND ENGINEERS

F. V. du Pont, Chairman....Wilmington
C. Douglas Buck, Member....Wilmington
Newton L. Grubb, Member....Grubbs
Charles W. Cullen, Member....Georgetown
J. Henry Hazel, Member....Dover
W. W. Mack, Chief Engineer....Dover
Allen Craig, Secy....Dover
Samuel Knopf, Prin. Asst. Engr....Dover
A. G. Livingston, Bridge Engr....Dover

RESIDENT ENGINEERS

E. E. Downing....Wilmington
William McWilliams....Dover
J. R. Hitchens....Georgetown

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Kent	James B. Bice, County Engineer	Dover
New Castle	Alban P. Shaw, County Engineer	Wilmington
Sussex	R. C. Hill, County Engineer	Georgetown

FLORIDA
STATE ROAD DEPARTMENT
Tallahassee

COMMISSION

C. B. Treadway, Chairman....Tallahassee
W. R. Gall, Commissioner....Zephyrhills
Roy V. Ott, Commissioner....Ocala
W. P. Mooty, Commissioner....Miami
J. R. Asbell, Commissioner....Panama City
B. M. Duncan, Consulting Engineer....Tallahassee

DEPARTMENT ENGINEERS

L. K. Cannon, Assistant Highway Engineer....Tallahassee
W. I. Nolen, Bridge Engineer....Tallahassee
H. C. Weathers, Testing Engineer....Gainesville
Thomas S. Beard, Supervisor of Equipment....Gainesville
J. H. Dowling, Chief Engineer....Tallahassee
H. M. Birtley, Purchasing Agent....Tallahassee
C. P. Datson, Chief Draftsman....Tallahassee

DIVISION ENGINEERS

H. L. Furlow, District No. 1....Lakeland
L. B. Thrasher, District No. 2....Jacksonville
E. K. Fogg, District No. 3....Panama City
E. S. Lofberg, District No. 4 North....Jacksonville
R. L. Bow, District No. 4 South....West Palm Beach

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Alachua	Byron Crow, County Surveyor	Gainesville
Baker	W. W. Eddy, County Surveyor	Macclenny
Bradford	J. Kickliter, Jr., County Surveyor	Starke
Brevard	L. R. Paxton, County Surveyor	Titusville
Broward	J. F. Charlton, County Surveyor (H. C. Davis, County Engineer)	Fort Lauderdale
Calhoun	J. H. Davis, County Surveyor	Blountstown
Charlotte	F. J. Bowen, County Surveyor	Punta Gorda
Clay	A. G. Shands, County Commr.	Green Cove Springs
Collier	A. W. Frederick, County Engineer	Everglades
Dade	Chas. Hannock, County Surveyor	Miami
Desoto	M. H. Harrison, Commissioner	Arcadia
Duval	Earl Luce, County Engineer	Jacksonville
Flagler	D. B. Roberts, County Engineer	Bunnell
Gadsden	E. H. Slappey, County Commissioner	Havanna
Glades	J. E. Frierson, Commissioner	Moore Haven
Hardee	Geo. E. Ralph, County Engineer	Wauchula
Hendry	C. Harold Mordoff, County Surveyor	Labelle
Hernando	H. S. Simmons, County Surveyor	Brooksville
Hillsboro	Thomas Beaty, County Surveyor (E. W. Carroll, County Engineer)	Tampa
Holmes	D. C. French, County Surveyor	Bonifay
Jackson	S. L. Daniel, County Surveyor	Marianna
Lafayette	W. O. Cannon, County Surveyor	Mayo
Lake	J. F. Lacey, County Surveyor	Tavares
Leon	E. G. Chesley, County Surveyor	Tallahassee
Madison	Chas. S. Wadsworth, County Surveyor	Madison
Marion	W. A. Moorehead, County Surveyor	Ocala
Martin	William H. Roat, County Surveyor	Stuart
Okaloosa	T. Holley, Commissioner	Laurel Hill
Okeechobee	Harmon Chandler, County Survr.	Okeechobee
Orange	Chas. A. Browne, Chief Engineer	Orlando
Osceola	Jos. E. Johnston, County Engineer	Kissimmee
Pasco	William A. Sparkman, County Surveyor	Dade City
Pinellas	C. E. Burleson, County Engineer	Clearwater
Polk	J. T. Hancock, County Surveyor (Alonzo Logan, County Commissioner)	Bartow
Putnam	L. E. Brunner, County Surveyor	Palatka
Santa Rosa	C. H. Overman, County Commissioner	Bagdad
Sarasota	J. F. Miller, County Commissioner	Sarasota
Sumter	D. L. Baker, County Surveyor	Bushnell
Volusia	W. S. Cowart, County Surveyor	DeLand
Wakulla	L. E. Hofma, County Surveyor	Crawfordville
Walton	Walker Green, Commissioner	Argyle
Washington	Thomas Collins, County Surveyor	Vernon

GEORGIA
STATE HIGHWAY DEPARTMENT
East Point

STATE HIGHWAY BOARD

W. E. Wilburn, Chairman, 2 Capitol Sq....Atlanta
Max L. McRae, Commissioner, 2 Capitol Sq....Atlanta
John A. Heck, Commissioner, 2 Capitol Sq....Atlanta

DEPARTMENT STAFF

B. A. Alderman, Chief Draftsman, 2 Capitol Sq....Atlanta
Spot Grant, Purchasing Agent, 2 Capitol Sq....Atlanta
M. E. Cox, State Highway Engineer, 2 Capitol Sq..Atlanta
C. N. Crocker, Bridge Engineer, 2 Capitol Sq....Atlanta
G. C. Blount, Maintenance Engineer, 2 Capitol Sq...Atlanta
J. E. Boyd, Materials and Resident Engineer, 2 Capitol Sq. ....Atlanta

MAINTENANCE SUPERVISORS

H. H. Johnson, Supervisor of Asphalt Force, 2 Capitol Sq. ....Atlanta
H. H. Price, Supervisor of Convict Forces, 2 Capitol Sq. ....Atlanta

DIVISION ENGINEERS

H. G. Smith, Division Engineer....Fitzgerald
E. Jack Smith, Division Engineer....Macon
L. J. Bahin, Division Engineer....East Point

COUNTY SURVEYORS AND ENGINEERS

County.	Official.	City.
Appling	C. R. Miles, County Surveyor	Baxley
Atkinson	B. J. Pearson, County Surveyor	Pearson
Bacon	J. W. Medders, County Surveyor	Alma
Baker	Reuben Brunson, County Surveyor	Newton
Baldwin	D. C. Page, Resident Engineer	Milledgeville
Banks	J. H. Brown, County Engineer	Homer
Barrow	C. W. Parker, County Surveyor	Winder
Bartow	L. A. House, County Surveyor	Cartersville
Ben Hill	W. C. Wilkinson, County Engineer	Fitzgerald
Bibb	H. D. Cutter, County Surveyor	Macon
Brantley	W. M. Robertson, County Engineer	Nahunta
Bulloch	J. E. Rushing, County Surveyor	Statesboro
Burke	G. F. Womble, County Engineer	Waynesboro
Butts	J. M. Collins, County Surveyor	Jackson
Carroll	O. B. Pierce, County Surveyor	Carrollton
Charlton	J. M. Wilds, County Surveyor	Folkston

Chatham—W. F. Brown, County Engineer.....Savannah
Chattahoochee—John Austin, County Surveyor.....Cusseta
Cherokee—Charles Killian, County Engineer.....Canton
Clarke—Homer Nicholson, County Engineer.....Athens
Clayton—W. J. Lee, County Surveyor.....Jonesboro
Cobb—W. McCullough, County Surveyor.....Marietta
Colquitt—A. D. Ross, County Surveyor.....Moultrie
Dade—M. G. Morrison, County Engineer.....Trenton
DeKalb—M. F. Mable, County Engineer and Surveyor .....Decatur
Dodge—J. W. Ard, County Engineer.....Eastman
Dougherty—Chas. G. Bennett, County Surveyor....Albany
Douglas—L. N. Price, County Surveyor.....Douglasville
Echols—W. V. Howell, County Surveyor.....Statenville
Effingham—D. M. Weitman, County Surveyor..Springfield
Elbert—R. W. Cleveland, County Surveyor.....Elberton
Emanuel—E. Warren, County Surveyor.....Swainsboro
Fayette—D. Davis, County Engineer.....Fayetteville
Floyd—Kiefe Lindsey, County Engineer.....Rome
Forsyth—H. A. Williams, County Surveyor.....Cumming
Fulton—H. N. Hurt.....Atlanta
Gordon—Rex W. LeFevre, County Engineer.....Calhoun
Grady—E. L. Reagen, County Surveyor.....Cairo
Hall—A. C. Stringer, Road Supervisor.....Gainesville
Hancock—No County Road Official.....Sparta
Haralson—J. R. Bush, County Surveyor.....Buchanan
Hart—J. W. Warren, County Surveyor.....Hartwell
Henry—No County Road Officials.....McDonough
Jackson—Geo. D. Appleby, County Engineer and Surveyor .....Jefferson
Jasper—W. A. Reid, County Surveyor.....Monticello
Jefferson—E. C. Slater, County Surveyor.....Louisville
Johnson—E. L. Douglas, County Surveyor....Wrightsville
Laurens—J. D. McLendon, County Surveyor.....Dublin
Lee—Forest Crotwell, County Surveyor.....Leesburg
Liberty—J. F. Zoru, County Surveyor.....Hinesville
Lincoln—W. A. Blackwell, County Surveyor....Lincolnton
Long—M. C. Garrason, County Surveyor.....Ludowici
Lowndes—B. Force, County Surveyor.....Valdosta
McDuffie—G. W. Lokey, County Engineer.....Thomson
Miller—A. H. Cook, County Engineer.....Colquitt
Mitchell—Ambrose Everett, County Surveyor.....Camilla
Monroe—J. H. Cook, County Engineer.....Forsyth
Morgan—John F. Cary, County Surveyor.....Madison
Murray—J. F. Harris, County Surveyor.....Chatsworth
Muscogee—Hugh McMath, County Surveyor....Columbus
Newton—W. A. Adams, County Surveyor.....Covington
Oconee—C. C. Parsons, County Highway Commissioner .....Watkinsville
Paulding—G. F. Lindsey, County Surveyor.....Dallas
Peach—T. F. Flournoy, County Surveyor.....Fort Valley
Pierce—L. H. Youmans, County Surveyor.....Blackshear
Polk—R. C. Knight, County Surveyor.....Cedartown
Putnam—D. C. Page, Resident Engineer.....Eatonton
Rabun—J. A. Reynolds, County Surveyor.....Clayton
Randolph—W. P. Earhartd, County Warden.....Cuthbert
Richmond—John D. Twiggs, County Surveyor....Augusta
Schley—S. B. Holstead, County Engineer.....Ellaville
Screven—A. L. Potter, County Surveyor.....Sylvania
Stewart—E. A. Morton, County Surveyor.....Lumkin
Sumter—C. H. Wheatley, County Engineer.....Americus
Talbot—B. M. Starling, County Surveyor.....Talbotton
Taylor—S. M. Trapp, County Surveyor.....Butler
Telfair—W. D. Hull, County Engineer.....McRae
Terrell—S. B. Denton, County Surveyor.....Dawson
Thomas—E. E. Bishop, County Surveyor.....Thomasville
Troup—A. D. Bradfield.....LaGrange
Twiggs—H. T. Pope, County Surveyor.....Jeffersonville
Upson—H. L. Crawley, County Engineer.....Thomaston
Walker—A. C. Veatch, County Engineer.....Lafayette
Webster—E. O. Hillsmann, County Surveyor.....Preston
Whitfield—R. F. Nelson, County Engineer.....Dalton
Wilkes—J. P. Bradley, County Surveyor.....Tignall
Worth—C. M. Medders, County Surveyor.....Sylvester

IDAHO

DEPARTMENT OF PUBLIC WORKS BUREAU OF HIGHWAYS

Boise

DEPARTMENT STAFF

G. E. McKelvey, Commissioner, Box 879.....Boise
J. H. Stemmer, Director of Highways.....Boise
C. A. Kyle, Bridge Engineer.....Boise
G. H. Petersen, Right of Way Engineer.....Boise
A. C. Blomgren, Aeronautics Engineer.....Boise
R. G. Gartner, Chief Draftsman.....Boise
G. H. Wetter, Purchasing Agent.....Boise
A. C. Waller, Materials and Oiling Engineer.....Boise
J. J. Jewell, Supervisor of Equipment.....Boise

DISTRICT ENGINEERS

A. D. Stanley.....Pocatello
J. M. Johnston.....Shoshone
J. J. McCreedy.....Lewiston
Lewis Roberts .....Boise
H. T. Evans.....Coeur d'Alene

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Ada	Earl P. Bennet, County Surveyor	Boise
Adams	Lee Highley, County Surveyor	Council
Bannock	W. P. Havenor, County Surveyor	Pocatello
Bear	Robert A. Birch, County Surveyor	Paris
Benewah	J. B. Sargent, County Surveyor	Saint Maries
Bingham	Fred Kiefer, County Surveyor	Blackfoot
Blaine	F. E. Drager, County Surveyor	Hailey
Boise	John A. Frey, County Surveyor	Idaho City
Bonner	Caryl W. Wilson, County Surveyor	Sandpoint
Bonnville	Al. J. Christensen, County Surveyor	Idaho Falls
Boundary	J. H. Cave, County Surveyor	Bonners Ferry
Butte	No County Surveyor	Arco
Camas	No County Surveyor	Fairfield
Canyon	John Griffiths, County Surveyor	Caldwell
Caribou	T. W. Cully, County Surveyor	Soda Springs
Cassia	Frank Beach, County Surveyor	Burley
Clark	E. W. Henninger, County Surveyor	Dubois
Clearwater	T. F. Edwards, County Surveyor	Orofino
Custer	J. Ray Weber, County Surveyor	Challis
Elmore	Lewis Rhinebold, County Survr.	Mountain Home
Franklin	Wilford Seamonds, County Surveyor	Preston
Fremont	J. W. Kenney, County Engineer	Saint Anthony
Gem	George W. Knowles, County Surveyor	Emmet
Gooding	W. R. Burkhardt, County Surveyor	Gooding
Idaho	E. C. Spedden, County Surveyor	Grangeville
Jefferson	Wm. J. Attridge, County Surveyor	Rigby
Jerome	L. T. Burdick, County Surveyor	Jerome
Kootenai	Wm. H. Pruitt, County Surveyor	Coeur d'Alene
Latah	Harry J. Smith, County Surveyor	Moscow
Lemhi	A. E. Ferguson, County Surveyor	Salmon
Lewis	Chas. Aldrich, County Surveyor	Nez Perce
Lincoln	Walter Chatfield, County Surveyor	Shoshone
Madison	Raymond Anderson, County Surveyor	Rexburg
Minidoka	A. L. Humphries, County Surveyor and Engineer	Rupert
Nez Perce	E. G. Wagner, County Surveyor	Lewiston
Oneida	T. F. Budge, County Surveyor	Malad City
Owyhee	No County Surveyor	Silver City
Payette	C. P. Lattig, County Surveyor and Engr.	Payette
Power	E. E. Zannig, County Commissioner (I. Allred, County Surveyor)	American Falls
Shoshone	T. Matt Halley, County Surveyor	Wallace
Teton	No County Surveyor	Driggs
Twin Falls	W. A. Minnich	Twin Falls
Valley	No County Surveyor	Cascade
Washington	J. R. Wood, County Surveyor	Weiser

ILLINOIS

DIVISION OF HIGHWAY DEPARTMENT OF PUBLIC WORKS AND BUILDINGS

Springfield

OFFICIALS AND ENGINEERS

Robert Kingery, Director of the Department of Public Works and Buildings, State House...Springfield
Ernst Lieberman, Chief Highway Engineer, Department of Public Works and Buildings, Division of Highways.....Springfield
C. E. DeLeuw, Assistant State Highway Engineer Department of Public Works and Buildings, Division of Highways.....Springfield
H. E. Surman, Engineer of Design, Department of Public Works and Buildings, Division of Highways .....Springfield
George Burch, Bridge Engineer, Department of Public Works and Buildings, Division of Highways .....Springfield

C. M. Hathaway, Construction Engineer, Department of Public Works and Buildings, Division of Highways .....Springfield
Fred Tarrant, Maintenance Engineer, Department of Public Works and Buildings, Division of Highways .....Springfield
V. L. Glover, Engineer of Materials, Department of Public Works and Buildings, Division of Highways .....Springfield

DISTRICT ENGINEERS

R. T. Cash, District No. 1.....Elgin
O. F. Goeke, District No. 2.....Dixon
M. J. Fleming, District No. 3.....Ottawa
Theo. Plack, District No. 4.....Peoria
C. H. Apple, District No. 5.....Paris
C. M. Slaymaker, District No. 6.....Springfield
P. F. Jervis, District No. 7.....Effingham
S. F. Wilson, District No. 8.....East St. Louis
G. A. Somerville, District No. 9.....Carbondale
Kendrick Harger, District No. 10.....Chicago

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Adams	Lewis L. Boyer, Supt. of Highways	Quincy
Alexander	D. E. Ball, Supt. of Highways	Cairo
Bond	R. O. Young, Supt. of Highways	Sorento
Boone	A. J. Van Epps, Supt. of Highways	Belvidere
Brown	W. O. Grover	Mount Sterling
Bureau	R. L. Schoenberger, Supt. of Highways	Princeton
Calhoun	Wm. F. Fiedler, Supt. of Highways	Batchtown
Carroll	S. S. Campbell, Supt. of Highways	Mount Carroll
Cass	C. V. Dawson, Supt. of Highways	Beardstown
Champaign	R. F. Fisher, County Surveyor	Urbana
Christian	Boyd H. Dappert, County Surveyor	Taylorville
Clark	Van Tarble, County Surveyor	Marshall
Clay	Vergil Van Dyke, Supt. of Highways	Louisville
Clinton	John Goldsmith, Supt. of Highways	Carlyle
Coles	Howard Miller, Supt. of Highways	Charleston
Cook	L. Mongreig, Engineer of Cicero (G. A. Quinlan, Supt. of Highways)	Chicago
Crawford	Chas. L. Dees, Supt. of Highways	Oblong
Cumberland	J. A. Decker, Supt. of Highways	Toledo
DeKalb	Fred O. Larson, Supt. of Highways	Sycamore
DeWitt	Geo. W. Givens, Supt. of Highways	Clinton
Douglas	L. O. Hackett, Supt. of Highways	Tuscola
DuPage	E. L. Gates, Supt. of Highways	Wheaton
Edgar	J. S. Randall, County Surveyor	Paris
Edwards	Frank D. Mayes, County Surveyor	Albion
Effingham	Geo. T. Austin, County Surveyor	Effingham
Fayette	J. V. Wadell, Supt. of Highways	Vandalia
Ford	S. E. Wells, Supt. of Highways	Piper City
Franklin	E. A. Webb, Supt. of Highways	Benton
Fulton	E. C. Van Sickle, Supt. of Highways	Canton
Gallatin	W. T. Smyth, Supt. of Highways	Shawneetown
Greene	Paul F. Fenity, Supt. of Highways	Kane
Grundy	Chas. H. Moon, County Engineer	Morris
Hamilton	John M. Sneed, County Surveyor	McLeansboro
Hancock	Arch C. Williams, Supt. of Highways	Carthage
Hardin	Clyde B. Soward, Supt. of Hghwys.	Elizabethtown
Henderson	E. C. Fort, Supt. of Highways	Stronghurst
Henry	J. H. Reed, Supt. of Highways	Cambridge
Iroquois	H. E. Crossland, Supt. of Highways	Watseka
Jackson	Ray S. Huffman, Supt. of Highways	Carbondale
Jasper	S. A. Conner, Supt. of Highways	Newton
Jefferson	Jas. Payne, Supt. of Highways	Mount Vernon
Jersey	Eugene Witt, County Supt. of Hghwys.	Jerseyville
JoDaviess	George Schroeder, Supt. of Highways.	Stockton
Johnson	C. A. Hook, Supt. of Highways	Vienna
Kane	C. L. Hanson, Supt. of Highways	Geneva
Kankakee	August C. Radkee, Supt. of Hghwys.	Kankakee
Kendall	J. D. Hollenback, Temporary Supt. of Highways	Millington
Knox	A. R. Smith, Supt. of Highways	Galesburg
Lake	R. M. Lobdell, Supt. of Highways	Waukegan
LaSalle	Geo. L. Farnsworth, County Surveyor	Ottawa
Lawrence	R. I. Benifiel, Supt. of Highways.	Lawrenceville
Lee	Fred Leake, Supt. of Highways	Dixon
Livingston	Glenn D. Butzer, Supt. of Highways	Pontiac
Logan	E. J. Tobin, Supt. of Highways	Lincoln
Macon	Paul T. Oetzel, Supt. of Highways	Decatur
Macoupin	William Yowell, Supt. of Highways	Carlinville
Madison	W. E. Howden, Supt. of Highways.	Edwardsville
Marion	W. L. Baker, Supt. of Highways	Salem
Marshall	O. W. Boers, Supt. of Highways	Lacon
Mason	C. H. Kreiling, County Surveyor	Havana
Massac	R. H. Austin, Supt. of Highways	Metropolis
McDonough	Phillip Lewis, Supt. of Highways	Macomb
McHenry	George L. Tryon, County Surveyor	Woodstock
McLean	P. J. Keller, Supt. of Highways	Bloomington
Menard	James Benson, Supt. of Highways	Petersburg
Mercer	Geo. A. Litzenberger, Supt. of Highways	Aledo
Monroe	A. R. Gardner, Supt. of Highways	Waterloo
Montgomery	Wm. Baird, Supt. of Highways	Hillsboro
Morgan	M. J. Benscoter, County Surveyor	Jacksonville
Moultrie	Guy S. Little, Supt. of Highways	Sullivan
Ogle	Alex Anderson, Supt. of Highways	Oregon
Peoria	Everett J. Wendell, Supt. of Highways	Peoria
Perry	Orlie Provart, County Supt. of Highways.	Du Quoin
Piatt	J. Robt. Bower, Supt. of Highways	Bement
Pike	Roy Likes, Supt. of Highways	Pittsfield
Pope	Geo. Manson, County Surveyor	Dixon Springs
Pulaski	W. N. Moyers, County Surveyor	Mound City
Putnam	H. S. Morine, Supt. of Highways	Hennepin
Randolph	J. R. Rankin, Supt. of Highways	Sparta
Richland	Ed. A. Phillips, Supt. of Highways	Olney
Rock Island	Wallace Treichler, Supt. of Highways	Rock Island
St. Clair	B. C. McCurdy, Supt. of Highways	Belleville
Saline	Ralph D. Brown, Supt. of Highways	Harrisburg
Sangamon	J. L. Todson, Supt. of Highways	Springfield
Scott	Joe A. Young, Supt. of Highways	Glasgow
Schuyler	H. H. Lawler, Supt. of Highways	Rushville
Shelby	Sylvester Clawson, Supt. of Highways.	Shelbyville
Stark	David Sharkey, County Surveyor	Toulon
Stephenson	O. G. Hively, Supt. of Highways	Freeport
Tazewell	E. Mitchell, County Surveyor	Delavan
Union	J. F. Howenstein, County Surveyor	Anna
Vermillion	W. S. Dillon, Supt. of Highways	Danville
Wabash	L. H. Murray, Supt. of Highways.	Mount Carmel
Warren	T. J. Bonderer, Supt. of Highways	Monmouth
Washington	O. C. Rabenneck, Supt. of Hghwys.	Nashville
Wayne	Frank E. Roberts, Supt. of Highways	Fairfield
White	G. H. Brown, Supt. of Highways	Carmi
Whitsides	E. O. Hill, Supt. of Highways	Morrison
Will	G. H. Fletcher, Supt. of Highways	Joliet
Williamson	Geo. H. Anderson, Supt. of Highways.	Herrin
Winnebago	A. R. Carter, Supt. of Highways	Rockford
Woodford	A. B. Hurd, Supt. of Highways	Eureka

INDIANA
STATE HIGHWAY COMMISSION
State House
Indianapolis

COMMISSION

James D. Adams, Chairman.....Indianapolis
Evan B. Stotsenburg, Commissioner.....Indianapolis
John W. Wheeler, Member.....Indianapolis

DEPARTMENT STAFF

M. R. Keefe, Chief Engineer.....Indianapolis
Fred Kellam, Engineer of Design.....Indianapolis
F. Y. Hardy, Engineer of Bridges.....Indianapolis
W. H. Skinner, Purchasing Agent.....Indianapolis
S. G. Cohen, Construction Engineer.....Indianapolis
C. W. McClain, Maintenance Engineer.....Indianapolis
C. E. Vogelsesang, Plan Engineer.....Indianapolis
L. S. Busch, Supervisor of Equipment.....Indianapolis
J. T. Hallett, Assistant Chief Engineer.....Indianapolis
P. D. Misenhelder, Materials and Res. Engr.....Indianapolis
W. M. Batchelor, Right of Way Engineer.....Indianapolis
H. O. Wimsett, Locating Engineer.....Indianapolis

DISTRICT ENGINEERS

Walter D. Irick, District Engineer, Box 226.Crawfordsville
Roy Biberstine, District Engineer, 347 W. Berry St. .....Fort Wayne
F. A. Henning, District Engineer, Box 150.....Greenfield
Oliver Downs, District Engineer, Box 428.....LaPorte
Ray H. Bower, District Engineer, Box 70.....Seymour
Glen Allen, District Engineer, Box 407.....Vincennes

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Adams	Ralph Roop, County Surveyor	Decatur
Allen	Harry K. Gottschalk, County Surveyor.	Fort Wayne
Bartholomew	Lloyd Rogers, County Surveyor.	Columbus
Benton	Dean Whicker, County Engineer	Fowler
Blackford	W. A. Brown, County Surveyor.	Hartford City

Boone—O. J. Brookshire, County Surveyor.....Lebanon
Brown—John Brown, County Surveyor.....Nashville
Carroll—Samuel Dyer, County Surveyor.....Delphi
Cass—Roy Hyman, County Surveyor.....Logansport
Clark—K. W. Barnes, County Engineer and Surveyor .....Jeffersonville
Clay—Edgar Schauwecker, County Surveyor.....Brazil
Clinton—Herbert Louck, County Surveyor.....Frankfort
Crawford—S. F. Tucker, County Surveyor.....Taswell
Daviess—Michael T. Madden, County Surveyor.Washington
Dearborn—A. W. Karsteter, County Engr...Lawrenceburg
Decatur—Geo. Kelley, County Surveyor.....Greensburg
DeKalb—Calvin C. Kain, County Surveyor.....Auburn
Delaware—Lester Janney, County Surveyor.....Muncie
Dubois—Carl J. Heim, County Surveyor.....Jasper
Elkhart—Ben E. Wise, County Surveyor.....Goshen
Fayette—Maurice Sholl, County Surveyor.....Connersville
Floyd—Albert Greybrook, County Engineer...New Albany
Fountain—Dewey Boggs, County Surveyor.....Covington
Franklin—A. W. Bruns, County Surveyor.....Brookville
Fulton—Walter Wilson, County Road Engineer and Surveyor .....Rochester
Gibson—H. Morrison, County Surveyor.....Princeton
Grant—Verlie Dicken, County Surveyor.....Marion
Greene—Henry G. Schloot, County Surveyor....Bloomfield
Hamilton—Roy Horney, County Surveyor.....Noblesville
Hancock—Gil Wilson, County Surveyor.....Greenfield
Harrison—Clarence Wolfe, County Surveyor.....Corydon
Hendricks—Carl E. Logan, County Surveyor.....Danville
Henry—Wm. H. Sorrell, County Surveyor.....Newcastle
Howard—Geo. H. Morrow, County Surveyor.....Kokomo
Huntington—Edw. E. Collins, County Engr...Huntington
Jackson—Emil F. Zabel, County Engineer and Surveyor .....Brownstown
Jasper—Edgar D. Nesbitt, County Supt. of Highways .....Rensselaer
Jay—Isaac R. Lyons, County Surveyor.....Portland
Jefferson—Ronald Horton, County Surveyor.....Madison
Jennings—Jos. H. Miller, County Surveyor.....Vernon
Johnson—Ivan Craggs, County Surveyor.....Franklin
Knox—Glen Sandefer, County Engineer.....Vincennes
Kosciusko—Robt. J. Pfleiderer, County Surveyor...Warsaw
Lagrange—Jas. R. Bridges, County Engineer and Surveyor .....LaGrange
Lake—Edwin F. Schoenbeck, County Engineer.Crownpoint
LaPorte—John Kelly, County Surveyor.....LaPorte
Lawrence—Frank S. Owen, County Surveyor.....Bedford
Madison—Paul Phipps, County Surveyor.....Anderson
Marion—Bruce Short, County Engineer.....Indianapolis
Marshall—Wm. Whitesell, County Supt. of Highways (H. D. Grube, County Surveyor).....Plymouth
Martin—Harry Gerkin, County Surveyor.....Shoals
Miami—Hugh C. Wagner, County Surveyor.....Peru
Monroe—Fred Huntington, County Engineer..Bloomington
Montgomery—Kenneth K. Buser, County Surveyor .....Crawfordsville
Morgan—H. A. Blunk, County Surveyor.....Martinsville
Newton—J. W. Roadruck, County Surveyor.....Kentland
Noble—Harry H. Mortorff, County Engineer.....Albion
Ohio—Roy L. Gibson, County Surveyor.....Rising Sun
Orange—Rufus E. Pinnick, County Engineer.....Paoli
Owen—D. R. Childress, County Surveyor.....Spencer
Parke—Ertus V. Burton, County Engineer.....Rockville
Pike—Gillie Barnes, County Surveyor.....Petersburg
Porter—G. F. Stinchland, County Surveyor.....Valparaiso
Posey—U. G. Emge, County Surveyor.....Mount Vernon
Pulaski—George Pugh, County Surveyor.....Winamac
Putnam—Arthur Plummer, County Surveyor...Greencastle
Randolph—Arthur B. Purdy, County Surveyor..Winchester
St. Joseph—Earl R. Feldman, County Engineer.South Bend
Scott—Theo. Williams, County Surveyor.....Scottsburg
Shelby—Earl Mings, County Surveyor.....Shelbyville
Spencer—Russell Ryan, County Surveyor.....Rockport
Starke—Geo. L. Savery, County Surveyor.....Knox
Steuben—Floyd Smith, County Surveyor.....Angola
Sullivan—L. A. Stewart, County Supt. Highways..Sullivan
Switzerland—William Morrison, County Engineer...Vevay
Tippecanoe—Geo. L. Balfe, County Surveyor.....Lafayette
Tipton—J. O. Bowlin, County Surveyor.....Tipton
Union—Ray Stout, County Engineer.....Liberty
Vanderburg—Mack W. Saunders, County Engr..Evansville
Vermillion—William Williams, County Surveyor..Newport
Vigo—Chas. C. Modesitt, County Engineer....Terre Haute
Wabash—Asher Gray, County Surveyor.....Wabash
Warren—J. Rupert Gregory, County Engineer and Surveyor .....Williamsport
Warrick—Bourcke C. Samples, County Surveyor..Boonville
Washington—John C. Prow, County Surveyor.....Salem
Wayne—G. F. Gault, County Surveyor.....Richmond
White—Lloyd Bridge, County Surveyor.....Monticello
Whitley—Oscar T. Schinbeckler, County Engineer .....Columbia City

IOWA
STATE HIGHWAY COMMISSION
Ames

COMMISSION

Carl C. Riepe, Chairman.....Burlington
Thomas A. Way, Commissioner.....Des Moines
W. D. Archie, Commissioner.....Sidney
O. J. Ditto, Commissioner.....Sibley
H. A. Maine, Commissioner.....Waterloo

DEPARTMENT STAFF

Fred R. White, Chief Engineer.....Ames
F. H. Mann, Assistant Chief Engineer and Constr....Ames
W. H. Root, Maintenance Engineer.....Ames
C. Coykendall, Administration Engineer.....Ames
W. E. Jones, Design Engineer.....Ames
Bert Myers, Mat. and Tests Engineer.....Ames
H. O. Parsons, Auditor.....Ames

DISTRICT ENGINEERS

W. F. Beard, District No. 1.....Ames
R. R. Zack, District No. 2.....Mason City
E. W. Dunn, District No. 3.....Sioux City
L. M. Martin, District No. 4.....Council Bluffs
J. S. Morrison, District No. 5.....Ottumwa
J. A. Paulson, District No. 6.....Cedar Rapids

COUNTY HIGHWAY ENGINEERS

County.	Official.	City.
Adair	F. A. Malcolm, County Engineer	Greenfield
Adams	Fred D. McClelland	Corning
Allamakee	Harry Orr	Waukon
Appanoose	R. C. Craig	Centerville
Audubon	F. W. Sarvis	Audubon
Benton	M. A. Hall	Vinton
Black Hawk	O. C. Thompson	Waterloo
Boone	R. E. Patterson	Boone
Bremer	W. S. Chapman	Waverly
Buchanan	R. W. Gearheart	Independence
Buena Vista	A. H. Cunningham	Storm Lake
Butler	O. W. Zack	Allison
Calhoun	W. E. McClure	Rockwell City
Carroll	J. F. Mahler	Carroll
Cass	Guy F. Canon-Darrow Blake, County Engs.	Atlantic
Cedar	R. O. Zimmerling	Tipton
Cerro Gordo	R. E. Robertson	Mason City
Cherokee	Floyd G. Rubey	Cherokee
Chickasaw	F. W. Lyford	New Hampton
Clarke	L. W. McKinley	Osceola
Clay	Floyd Campbell	Spencer
Clayton	E. W. Hahn	Elkader
Clinton	E. B. Lorensen	Clinton
Crawford	W. J. Wearmouth	Denison
Dallas	J. C. Buckman	Adel
Davis	Arnold Krane	Bloomfield
Decatur	Floyd K. Brown	Leon
Delaware	H. Klaus	Manchester
Des Moines	J. F. Winters	Burlington
Dickinson	R. A. Furman	Spirit Lake
Dubuque	A. A. Roomberg	Dubuque
Emmet	L. L. Boggess	Estherville
Fayette	A. D. Finch	West Union
Floyd		Charles City
Franklin	C. P. Rudisill	Hampton
Fremont	R. H. Greenwood	Sidney
Greene	S. J. Melson	Jefferson
Grundy	J. W. Wiersma	Grundy Center
Guthrie	L. S. Gates	Guthrie Center
Hamilton	M. Y. Kinne	Webster City
Hancock	C. F. Merten	Garner
Hardin	E. E. Hogeland	Eldora
Harrison	Thomas A. Cherry	Logan
Henry	C. E. Smith	Mount Pleasant
Howard	L. L. Lowery	Cresco
Humboldt	S. M. Helgeland	Humboldt
Ida	George S. Witters	Ida Grove

Iowa—W. K. Chantry.....Marengo
Jackson—T. E. Riley.....Maquoketa
Jasper—Ray MacMurray.....Newton
Jefferson—M. H. Bryant.....Fairfield
Johnson—G. M. Griffith.....Iowa City
Jones—E. G. Henningsen.....Anamosa
Keokuk—R. C. Frye.....Sigourney
Kossuth—H. M. Smith.....Algona
Lee—M. F. McFarland.....Fort Madison
Linn—Wm. H. Behrens.....Cedar Rapids
Louisa—A. W. Hindermon.....Wapello
Lucas—A. R. Bartell.....Chariton
Lyon—E. B. Carson.....Rock Rapids
Madison—T. S. Farquharson.....Winterset
Mahaska—R. H. Tumy.....Oskaloosa
Marion—R. T. Johnson.....Knoxville
Marshall—D. C. Elder.....Marshalltown
Mills—T. E. Martin.....Glenwood
Mitchell—C. P. Goplerud.....Osage
Monona—R. A. Rawlings.....Onawa
Monroe—E. R. Seidel.....Albia
Montgomery—P. A. Michel.....Red Oak
Muscatine—F. P. G. Halbfass.....Muscatine
O'Brien—W. L. Anderson.....Primghar
Osceola—Edward Winkel.....Sibley
Page—W. P. Norris.....Clarinda
Palo Alto—T. R. Martin.....Emmettsburg
Plymouth—M. B. Starr.....Le Mars
Pocahontas—A. L. Thornton.....Pocahontas
Polk—F. O. Laing.....Des Moines
Pottawattamie—P. V. Saum.....Council Bluffs
Poweshiek—C. E. Olson.....Montezuma
Ringgold—C. H. Lehmkuhl.....Mt. Ayr
Sac—Bert D. Jones.....Sac City
Scott—J. M. Malloy.....Davenport
Shelby—J. P. Camery.....Harlan
Sioux—K. L. Seliger.....Orange City
Story—S. Stiegerwalt.....Nevada
Tama—H. E. Rager.....Toledo
Taylor—S. R. Weir.....Bedford
Union—Arthur K. Olsen.....Creston
Van Buren—Geo. Aldrich.....Keosauqua
Wapello—H. E. Hansel.....Ottumwa
Warren—D. L. Thomas.....Indianola
Washington—W. P. Rawn.....Washington
Wayne—R. Brady.....Corydon
Webster—C. A. Snook.....Fort Dodge
Winnebago—Gerald S. Jones.....Forest City
Winneshiek—F. W. Arneson.....Decorah
Woodbury—J. C. McLean.....Sioux City
Worth—Thomas T. Teall.....Northwood
Wright—T. F. Matson.....Clarion

KANSAS

STATE HIGHWAY COMMISSION

Topeka

COMMISSION

Lynn R. Brodrick.....Marysville
E. A. Pinkerton.....Glasco
L. N. Drelling.....Penokee
Earle C. Todd.....Independence
G. S. Renn.....Wellington
E. C. Bray.....Syracuse

DEPARTMENT STAFF

Harry Darby, Director of Highways.....Topeka
Gertrude Whitcomb, Secretary.....Topeka
W. V. Buck, State Highway Engineer.....Topeka
H. D. Barnes, Engineer of Construction.....Topeka
O. J. Eidmann, Engineer of Design.....Topeka
I. E. Taylor, Engineer of Maintenance.....Topeka
W. L. Dyatt, Office Engineer.....Topeka
H. R. Goodyear, Auditor.....Topeka
Wint Smith, Attorney.....Topeka

DIVISION ENGINEERS

T. E. Burton, Div. No. 1.....Topeka
L. J. Siler, Div. No. 2.....Salina
R. C. Keeling, Div. No. 3.....Norton
J. F. Grady, Div. No. 4.....Chanute
R. B. Wills, Div. No. 5.....Hutchinson
J. A. Roby, Div. No. 6.....Garden City

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Allen	A. W. Young, County Engineer	Iola
Anderson	Fred Gardener, County Engineer	Garnett
Atchison	R. D. Coleman, County Engineer	Atchinson
Barber	L. A. Tilton, County Engineer	Medicine Lodge
Barton	J. M. Hall, County Engineer	Great Bend
Bourbon	G. C. Thompson, County Engineer	Fort Scott
Brown	S. K. McCrary, County Engineer	Hiawatha
Butler	J. R. Switzer, County Engineer	El Dorado
Chase	Jas. McKinzie, County Engineer	Cottonwood Falls
Chautauqua	C. E. Fesler, County Engineer	Sedan
Cherokee	Lloyd Belt, County Engineer	Columbus
Cheyenne	E. M. Scoby, County Engineer	St. Francis
Clark	C. E. Hommon, County Engr. and Surv.	Ashland
Clay	Malloy Quinn, County Engineer	Clay Center
Cloud	A. R. Senter, County Surveyor	Concordia
Coffey	F. E. Wagner, County Engineer	Burlington
Comanche	Weldo Wollam, County Engineer	Coldwater
Cowley	Blair Boyle, County Engineer	Winfield
Crawford	P. B. Smith, County Engineer	Pittsburg
Decatur	E. W. Woolley, County Engineer	Oberlin
Dickinson	Carl L. Nicolay, County Engr. & Surv.	Abilene
Doniphan	H. L. Parker, County Engineer	Troy
Douglas	E. E. Trueblood, County Engineer	Lawrence
Edwards	E. B. Johnson, County Engineer	Kingsley
Elk	C. B. Alexander, County Engineer	Howard
Ellis	C. J. Loreditsch, County and Resident Engr.	Hays
Ellsworth	S. E. Foster, County Engineer	Ellsworth
Finney	Ben L. Allen, County Engineer	Garden City
Ford	R. C. Ham, County Surveyor	Dodge City
Franklin	Robert F. Mason, County Engineer	Ottawa
Geary	C. M. Smitley, County Engineer	Junction City
Gove	Frank D. Tyson, County Engineer	Gove
Graham	R. W. Baird, (Acting) County Engr.	Hill City
Grant	C. W. Hickok, County Engineer	Ulysses
Gray	R. S. Kirk, County Engineer	Cimarron
Greeley	S. F. Holmes, County Engineer	Tribune
Greenwood	Wm. Faulkner, County Engr. & Surv.	Eureka
Hamilton	Frank Petefish, County Engineer	Syracuse
Harper	H. K. Shideler, County Engineer	Anthony
Harvey	J. W. Mavity, County Engineer	Newton
Haskell	C. R. Tillitson, County Engineer	Sublette
Hodgeman	Earl Lonnberg, County Engineer	Jetmore
Jackson	P. W. Wright, County Engineer	Holton
Jefferson	H. L. Watchous, County Engineer	Oskaloosa
Jewell	L. G. Morphy, County Engineer	Mankato
Johnson	S. P. Eberhart, County Engineer	Olathe
Kearney	A. K. Brown, County Engr. and Surv.	Lakin
Kingman	C. C. Martin, County Surveyor	Kingman
Kiowa	Jack Schall, County Engineer	Greensburg
Labette	J. R. Jarboe, County Engineer	Oswego
Lane	E. L. Leman, County Engineer	Dighton
Leavenworth	J. E. McCorkle, County Engr.	Leavenworth
Lincoln	Fred Smart, County Engineer	Lincoln
Linn	C. E. Kenny, County Engineer	Mound City
Logan	W. M. Biays, County & Res. Engr.	Russell Springs
Lyon	O. D. Henry, County Surveyor	Emporia
Marion	Jas. F. Meisner, County Engineer	Marion
Marshall	L. R. Eaton, County Engineer	Marysville
McPherson	Guy Hall, County Engineer	McPherson
Meade	H. L. Gillman, County Engineer	Meade
Miami	Harry Abbey, County Engineer	Paola
Mitchell	J. P. Boesche, County Engr. and Surv.	Beloit
Montgomery	H. K. Hibbard, County Engr.	Independence
Morris	F. S. Williamson, Co. Engr. & Surv.	Council Grove
Morton	E. C. Dean, County Engineer	Richfield
Nehama	L. P. Price, County Engineer	Seneca
Neosho	John Huston, County Engineer	Erie
Ness	L. I. Hunt, County Engr. and Surveyor	Ness City
Norton	F. C. Haelea, County Engineer	Norton
Osage	C. Nolan Harper, County Engineer	Lyndon
Osborne	H. R. Hillman, County Engineer	Osborne
Ottawa	Lloyd R. Miller, County Engineer	Minneapolis
Pawnee	L. D. Harris, County Engineer	Larned
Phillips	Everett Hoffhines, County Engineer	Phillipsburg
Pottawattomie	L. W. Whearty, Co. Engr.	Westmoreland
Pratt	Dave Burnett, County Engineer (Acting)	Pratt
Rawlins	Clay Hildebrand, County Engineer	Atwood
Reno	Fred Mills, County Engineer	Hutchinson
Republic	V. B. Fredenhagen, County Engineer	Belleville
Rice	A. S. Little, County Engineer and Surveyor	Lyons
Riley	W. D. Cole, County Engineer	Manhattan
Rooks	R. I. Britton, County Engineer	Stockton
Rush	J. R. Miller, County Engineer and Surv.	La Crosse
Russell	Earl L. Preston, County Engineer	Russell
Saline	W. H. Cost, County Engineer	Salina

Scott—Frank Robb, County Engineer and Surv..Scott City
Sedgwick—E. A. Merydith, County Engineer.....Wichita
Seward—W. E. Williams, County Engineer.....Liberal
Shawnee—Jas. Irons, County Engineer.....Topeka
Sheridan—A. J. Mowery, County Engineer.....Hoxie
Sherman—Hal Everett, County Engr. (Resident).Goodland
Smith—Ray D. Hutchins, County Engineer...Smith Center
Stafford—Jas. Starke, County Engineer.....St. John
Stanton—I. R. Streeter, County Engineer.....Johnson
Stevens—W. B. Crawford, County Engineer.....Hugoton
Sumner—R. S. Kirk, County Engineer.....Wellington
Thomas—W. O. Williams, County Engineer.....Colby
Trego—H. Harlan, County Engineer.....Wakeeney
Wabaunsee—F. Itz, County Engineer and Surveyor...Alma
Washington—J. H. Pierce, County Engineer...Washington
Wichita—F. B. Robb, County Engineer.....Leoti
Wilson—E. C. Baity, County Engineer.....Fredonia
Woodson—H. O. Ashley, Co. Engr. and Surv..Yates Center
Wyandotte—Leroy Arnold, County Engineer..Kansas City

KENTUCKY
STATE HIGHWAY DEPARTMENT
Frankfort

COMMISSION

Ben Johnson, Chairman.....Bardstown
Chas. Fennell, Secretary.....Flemingsburg
W. C. Broadbent, Member.....Cadiz
G. L. Withers, Member.....Dixon
Thos. S. Rhea, Member.....Russellville
A. P. Plummer, Member.....Flemingsburg
Ed. M. Gatliff, Member.....Williamsburg
J. L. Donaldson, Member.....Carrollton
Zach Justice, Member.....Pikeville

DISTRICT ENGINEERS

G. L. Logan, Engineer of Construction.....Frankfort
T. B. Smith, Engineer of Maintenance.....Frankfort
H. R. Creal, Bridge Engr.....Frankfort
W. O. Snyder, Office Engr.....Frankfort
Robt. G. Terrell, Testing Engineer.....Frankfort
J. A. Spears.....Paducah
C. N. Hikes.....Morganfield
J. A. Reed.....Bowling Green
M. D. Ross.....Covington
F. A. Shobe.....Louisville
C. H. Wood.....Danville
R. R. Elliott.....Flemingsburg
Joe C. Young.....London
H. K. McCormick.....Pikesville

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Adair	C. F. Breeding, County Surveyor	Columbia
Allen	J. W. Crowe	Scottsville
Anderson	C. T. Case	Lawrenceburg
Barren	E. L. Rogers, County Surveyor	Glasgow
Bath	B. A. Shraut, County Surveyor	Owingsville
Bell	P. M. Sherwin	Pineville
Boone	A. L. Stephens, County Engineer	Burlington
Bourbon	Ben F. Bedford, County Engineer	Paris
Boyd	Fred W Gesling	Catlettsburg
Boyle	W. P. Caldwell	Danville
Bracken	Omar Myers, County Engineer	Brooksville
Breckenridge	W. Davis, County Engineer	Hardinsburg
Butler	A. J. Bradley	Morgantown
Caldwell	J. E. Pilant	Princeton
Calloway	T. Wade Crawford, County Surveyor	Murray
Campbell	Chas. J. Thiel, County Engineer	Alexandria
Carroll	Y. Ford	Carrollton
Carter	John L. Thornberry	Grayson
Casey	W. E. Carigan	Liberty
Christian	Allen Clardy, County Engineer	Hopkinsville
Clark	S. C. Boone	Winchester
Clay	No County Highway Engineer	Manchester
Clinton	W. H. Gibson, County Surveyor	Albany
Cumberland	R. D. Bass	Burkesville
Davies	J. W. Spurrier	Owensboro
Edmonson	M. L. Maxwell	Brownsville
Estell	Homer Tuttle	Irvine
Fayette	W. H. Edwards, County Engineer	Lexington
Fleming	M. F. Daugherty	Flemingsburg
Floyd	H. L. Mayo	Prestonburg
Garrard	Irvine Stapp, County Engineer	Lancaster
Grant	Jas. A. Rednower, County Engineer	Williamstown
Graves	Porter Dockrey, Resident Supt	Mayfield
Grayson	E. F. Awbrey	Leitchfield
Green	P. F. Marshall	Greensburg
Greenup	B. E. Secrest	Greenup
Hardin	S. B. Williams	Elizabethtown
Harlan	J. R. Carson,Jr	Harlan
Harrison	Chas. E. Hicks	Cynthiana
Hart	B. F. Bacon	Munfordville
Henderson	Elmer Hopkins, County Engineer	Henderson
Henry	R. H. Casey	New Castle
Jefferson	Merritt Drane, County Engineer	Louisville
Johnson	G. G. Auxier, County Surveyor	Paintsville
Kenton	H. G. Meiners	Covington
Knox	J. D. Tuggle	Barbourville
Lawrence	C. F. Smith, County Surveyor	Louisa
Leslie	J. Mattingly	Hyden
Letcher	Emmett Blair	Whitesburg
Lewis	M. Fannin, County Engineer	Vanceburg
Lincoln	E. D. Pennington, County Surveyor	Stanford
Logan	O. Z. Hutcheson, County Engineer	Russelville
McCracken	W. L. Warren, County Engineer	Paducah
McCreary	G. A. Bell, County Surveyor	Whitley City
McLean	T. H. Valentine	Calhoun
Madison	S. P. Bush	Richmond
Marshall	E. F. Cross	Benton
Mason	L. M. Collis	Maysville
Meade	W. A. Baskett, County Judge	Brandenburg
Metcalfe	R. B. DeMumbrun	Edmonton
Monroe	W. S. Harlan	Tompkinsville
Montgomery	W. H. Canan	Mount Sterling
Morgan	Floyd Craft, County Engineer	West Liberty
Nelson	R. Lee Beeler, County Engineer	Bardstown
Nicholas	P. D. Darnall	Carlisle
Ohio	James F. Stegers, Resident Engineer	Hartford
Oldham	Dick Ireland, County Engineer	LaGrange
Owen	I. L. Johnson, County Engineer	Owenton
Owsley	A. B. Seale	Boonville
Pike	A. Ford, County Engineer	Pikeville
Robertson	Wm. E. Mann	Mount Olivet
Scott	C. N. Woodward, County Engineer	Georgetown
Shelby	J. E. Robertson, County Engineer	Shelbyville
Simpson	O. Haydon, Jr	Franklin
Taylor	Fred Faulkner	Campbellsville
Todd	C. M. Duffy, County Surveyor	Elkton
Trimble	W. L. Harmon	Bedford
Warren	W. S. Campbell	Bowling Green
Washington	H. R. Eddleman	Springfield
Webster	A. L. Hall, County Judge	Dixon
Woodford	J. R. McCreight	Versailles

LOUISIANA
STATE HIGHWAY COMMISSION
Baton Rouge

COMMISSIONERS

A. P. Tugwell, Chairman.....Baton Rouge
J. M. Nugent, Vice-Chairman.....Baton Rouge
F. W. Raggio, Secretary.....Baton Rouge

DEPARTMENT STAFF

W. H. Norckauer, State Highway Engineer...Baton Rouge
N. E. Lant, Bridge Engineer.....Baton Rouge
E. L. Erickson, Assistant Bridge Engineer....Baton Rouge
J. R. Wendt, Maintenance Engineer.....Baton Rouge
J. M. Semmes, Assistant Maintenance Engr...Baton Rouge
J. A. Kinkead, Office Engineer.....Baton Rouge
J. P. McCullough, Right-of-Way Engineer....Baton Rouge
W. T. Cheek, Locating Engineer.....Baton Rouge
H. L. Lehmann, Physical Testing Engineer..Baton Rouge
Foster Couvillion, Purchasing Agent.....Baton Rouge
L. G. Vidrine, Auditor.....Baton Rouge
R. P. Greene, Traffic Manager.....Baton Rouge
E. P. Roy, Chief of Enforcement Dept.....Baton Rouge
H. S. Allen, Chief Engineering Auditor.....Baton Rouge
E. A. Caldwell, Principal Construction Engr..Baton Rouge
C. A. Ives, Construction Engineer.....Baton Rouge
B. P. Lyons, Bridge Construction Engineer...Baton Rouge

DISTRICT ENGINEERS

H. M. Weber, District Maintenance Supt.....Marrero

J. C. Waties, District Maintenance Supt.....Napoleonville
A. W. Williams, District Maintenance Supt.....New Iberia
B. F. Terry, District Maintenance Supt.....Lafayette
E. M. Scaraborough, District Maint. Supt..Lake Charles
B. E. Bickham, District Maintenance Supt.....Hammond
Geo. E. Oldham, District Maintenance Supt..Baton Rouge
B. F. Lewis, District Maintenance Supt.....Alexandria
F. E. Welch, District Maintenance Supt.....Winnfield
W. F. Cooper, District Maintenance Supt.....Winnsboro
W. H. Huckaby, District Maint. Supt., Box 996....Monroe
Geo. J. Bailey, District Maintenance Supt.....Arcadia
W. P. Carter, District Maintenance Supt.....Shreveport
Lewis L. Morgan, Attorney.....Baton Rouge

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Avoyelle	W. O. Chatelain, County Engineer	Marksville
Beauregard	R. A. Scalfi, Surv.; S. Bilbo, Engr.	De Ridder
Bienville	E. M. Cony, County Surveyor	Ringgold
Bossier	J. R. Honeycutt, County Engineer	Benton
Caddo	J. T. Bullen, Parish Engineer	Shreveport
Caldwell	R. N. T. Lovell, County Surveyor	Columbia
Calcasieu	Walter S. Goos, County Engineer	Lake Charles
Claiborne	W. M. Barber, County Surveyor	Homer
DeSoto	Joseph Bice, County Surveyor	Mansfield
East Baton Rouge	L. A. Huey, County Surv.	Baton Rouge
East Carroll	F. D. Bull, County Surv.	Lake Providence
East Feliciana	Clarence Percy, County Surveyor	Clinton
Franklin	J. W. Baker, County Surveyor	Winnsboro
Jefferson	J. H. Payne, Parish Engineer	Gretna
Jefferson	Chas. A. Hardie, County Surveyor	Gretna
Jefferson Davis	J. F. Harvey, County Surveyor	Jennings
LaFourche	No County Surveyor	Thibodaux
La Salle	No County Surveyor	Jena
Lincoln	No County Surveyor	Ruston
Madison	Frank L. Roe, Jr., County Surveyor	Tallulah
Morehouse	A. C. Volk, County Surveyor	Bastrop
Ouachita	R. A. Morrison, County Surveyor	Monroe
Plaquemines	John C. DeArmes, Jr., County Surveyor	Point a la Hache
Rapids	Ira W. Sylvester, Parish Engr.; H. J. Daigre, County Surveyor	Alexandria
Sabine	L. G. Edwards, County Surveyor	Many
Saint Landry	No County Surveyor	Opelousa
Saint Mary	L. A. Lenstaot, County Surveyor	Franklin
Saint Tammany	Homer G. Fritchie, Co. Surv.	Covington
Tangipahoa	Thom. A. Tycer, County Engineer	Amite
Tensas	No County Surveyor	St. Joseph
Vermilion	Ernst Montague, County Surveyor	Kaplan
Vernon	Curry Ford, County Surveyor	Leesville
Washington	Thos. E. Piggott, County Surv.	Franklinton
Webster	No County Surveyor	Minden
West Carroll	S. T. Jackson	Oak Grove
Winn	W. C. Cookston, County Surveyor	Winnfield

MAINE
STATE HIGHWAY COMMISSION
Augusta

COMMISSION

Frank A. Peabody, Chairman.....Houlton
Edw. E. Farnsworth.....South Portland
Paul S. Thurston.....Bethel

ENGINEERS

L. D. Barrows, Chief Engineer.....Augusta
E. L. Merrill, Assistant Engineer.....Augusta
M. L. Wilder, Bridge Engineer.....Augusta
R. M. Page, Office Engineer.....Augusta

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Kennebec	John H. Burleigh, Co. Engr. and Surv.	Augusta
Knox	No County Highway Engineer	Rockland
Piscataquis	E. J. Smith, County Engineer and Surveyor	Dover-Foxcraft
Somerset	No County Highway Engineer	Skowhegan
York	Roland W. Libby, County Engineer	Alfred

MARYLAND
STATE ROADS COMMISSION
Federal Reserve Bank Building
Baltimore

OFFICIALS AND ENGINEERS

G. Clinton Uhl, Chairman.....Baltimore
Robert Lacy, Commissioner.....Baltimore
E. Brooke Lee, Commissioner.....Baltimore
Lamar H. Steuart, Secretary.....Baltimore
W. P. Carrington, Treasurer.....Baltimore
R. F. Going, Purchasing Agent.....Baltimore
Harry D. Williar, Jr., Chief Engineer.....Baltimore
R. M. Reindollar, Assistant Chief Engineer.....Baltimore
Walter C. Hopkins, Bridge Engineer.....Baltimore
Austin F. Shure, Engineer of Surveys.....Baltimore
L. A. Kahn, Assistant to Chief Engineer.....Baltimore
F. P. Schrivener, Maintenance Engineer.....Baltimore
C. B. Bryant, Materials Engineer.....Baltimore
L. W. Kern, Right-of-way Agent.....Baltimore

DISTRICT ENGINEERS

P. A. Morison.....Salisbury
Rolph Townshend.....Chestertown
D. P. Campbell, Reckord Bldg.....Towson
E. C. Duncan.....Hyattsville
Thomas M. Linthicum.....Frederick
Leo T. Fowney.....Cumberland
Edw. H. Nunn.....Glen Burnie
Jos. Chaney.....Upper Marlboro

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Alleghany	Abolished 6-1-33	Cumberland
Anne	John A. Bromley	Annapolis
Baltimore	J. P. Grayson	Towson
Caroline	Harry Waldorf	Denton
Carroll	County Highway Commissioner	Westminster
Charles	H. H. Bowling, County Highway Com	La Plata
Dorchester	Henry Corkran, County Engineer	Cambridge
Frederick	Emory C. Crum, County Surveyor	Frederick
Garrett	C. Milton Sincell, County Surveyor	Oakland
Harford	W. F. Sommerville, County Surveyor	Bel Air
Howard	G. Hunter Sykes, County Surveyor	Ellicott City
Kent	G. B. Taylor, County Engineer	Chestertown
Montgomery	H. B. Shaw, County Engineer	Silver Spring
Prince Georges	E. L. Latimer, County Surveyor	Upper Marlboro
Queen Annes	J. R. E. Turpin	Centerville
Saint Marys		Leonardtown
Somerset	Samuel F. Miles, County Surveyor	Princess Anne
Talbot	Geo. R. Saymour	Easton
Washington	Edw. Schindel, County Surveyor	Hagerstown
Wicomico	Horace M. Clark, County Engineer	Salisbury
Worcester	Robert Shockley, County Engineer	Snow Hill

MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS
State House
Boston

COMMISSION

Frank E. Lyman, Commissioner.....Boston
Richard K. Hale, Associate Commr.....Boston
Herman A. MacDonald, Associate Commr.....Boston

DEPARTMENT STAFF

Arthur W. Dean, Chief Engr.....Boston
F. C. Pillsbury, Project Engr.....Boston
R. W. Coburn, Constr. Engr.....Boston
G. H. Delano, Maint. Engr.....Boston
George E. Harkness, Bridge Engr.....Boston
Arthur Larrabee, Office Asst. Engr.....Boston
A. V. Bratt, Chemist.....Boston

DISTRICT ENGINEERS
Highways

G. A. Curtis, Dist. No. 1.....Pittsfield
H. D. Phillips, Dist. No. 2.....Greenfield
J. A. Johnston, Dist. No. 3.....Worcester
F. D. Sabin, Dist. No. 4.....Brighton

J. E. Lawrence, Dist. No. 5.....Beverly
H. O. Parker, Dist. No. 6.....Taunton
H. C. Holden, Dist. No. 7.....Middleboro

Waterways

J. N. Ferguson.....Boston
F. L. Sellew.....Boston

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Essex	Robert R. Evans, County Commr	Salem
Hampden	No County Highway Commr	Springfield
Hampshire	E. E. Davis, County Commr	Northampton
Middlesex	F. H. Kendall, County Commr	Cambridge
Norfolk	Hartley L. White, County Commr	Dedham
Plymouth	Lewis W. Perkins, County Commr	Plymouth
Worcester	L. O. Marden, County Commr	Worcester

MICHIGAN
STATE HIGHWAY DEPARTMENT
Lansing

DEPARTMENT OFFICIALS AND ENGINEERS

Murray Van Wagoner, State Highway Commr....Lansing
G. Donald Kennedy, Bus. Mgr. and Con. Engr....Lansing
Harry C. Koons, Commr. and Chief Engineer.....Lansing
Varnum B. Steinbaugh, Road Engineer.....Lansing
Lester W. Millard, Bridge Engineer.....Lansing
E. Edwin Blomgren, Maintenance Engineer.....Lansing
John W. Kushing, Research and Testing Engineer..Lansing
Raymond F. Foley, Director of Public Relations..Lansing
Arthur F. Lederle, Director of Right-of-Way Dept.Lansing
Chas. F. Boehler, Engineer of Road Design.....Lansing
Carl D. Willman, Construction Engineer.....Lansing
James H. Cissel, Engineer of Bridge Design.....Lansing
James H. Flynn, Engineer of Bridge Construction..Lansing
Albert E. Fellers, Engineer of Bridge Maintenance.Lansing
Roscoe E. Hefron, Asst. Maintenance Engineer....Lansing
F. E. N. Thatcher, Statistical Engineer.....Lansing
Frank E. Simpson, Engineer of Road Plans.....Lansing

DISTRICT ENGINEERS

Parnell G. McKenna, District Engineer.....Plymouth
R. R. Havens, District Engineer.....Jackson
R. A. Beers, District Engineer.....Kalamazoo
E. G. Schwoppe, District Engineer.....Grand Rapids
P. D. Prentice, District Engineer.....Saginaw
H. F. Zumstein, District Engineer.....Port Huron
E. R. Luedtke, District Engineer.....Cadillac
A. M. Hopperstead, District Engineer.....Alpena
Benj. F. Sparks, Upper Peninsula Engineer.....Escanaba
E. H. Haahr, Upper Peninsula Engineer.....Newberry
L. N. Jones, Upper Peninsula Engineer.....Crystal Falls

COUNTY HIGHWAY OFFICIALS

County.	Official.	City
Alcona	No County Engineer	Harrisville
Alger	George Depew, County Engineer	Munising
Allegan	Glenn B. Cook	Allegan
Alpena	Jas. R. Brown, County Supt	Alpena
Antrim	No County Engineer	Bellaire
Arenac	No County Engineer	Standish
Baraga	No County Engineer	L'Anse
Barry	John Rakowsky, County Engineer	Hastings
Bay	No County Engineer	Bay City
Benzie	No County Engineer	Beulah
Berrien	John H. Bateman, County Engineer	St. Joseph
Branch	C. D. Goss, County Engineer	Coldwater
Calhoun	Roy M. Hodges, County Engineer	Marshall
Cass	No County Engineer	Dowagiac
Charlevoix	R. F. Sloan, Jr., County Engineer	Charlevoix
Cheboygan	No County Engineer	Cheboygan
Chippewa	L. F. Levin, County Engineer	Sault Ste. Marie
Clare	No County Engineer	Clare
Clinton	L. E. Belknap, County Engineer	St. Johns
Crawford	No County Engineer	Grayling
Delta	R. P. Mason, Supt. and Engineer	Escanaba
Dickinson	Geo. Tramp, Engineer	Iron Mountain
Eaton	H. A. Williams, Engineer and Manager	Charlotte
Emmett	R. D. Tripp, Engineer and Manager	Petoskey
Genesee	J. H. Dennis, County Surveyor	Flint
Gladwin	John M. Knox, County Engineer and Surveyor	Beaverton
Gogebic	Geo. W. Koronski, County Engineer	Bessemer
Grand Traverse	Walter Dow, County Surveyor	Traverse City
Hillsdale	Fred F. Rogers, County Engineer	Hillsdale
Houghton	C. F. Winkler, County Engineer	Hancock
Huron	L. L. Bateman, County Engineer	Bad Axe
Ingham	H. C. Coons, County Engineer	Mason
Ionia	A. M. Williams, County Engineer	Ionia
Iosco	J. N. Sloane, County Engineer	East Tawas
Iron	H. F. Larson	Crystal Falls
Isabella	No County Engineer	Mt. Pleasant
Jackson	E. K. MacAllister, County Engineer	Jackson
Kalamazoo	Leo J. Wykkel	Kalamazoo
Kent	O. S. Hess, Engineer and Manager	Grand Rapids
Kalkaska	H. L. Botsford, County Engineer	Kalkaska
Keweenaw	W. C. Veale, County Engineer	Ahmeek
Lake	Geo. E. Johnston, County Engineer and Surveyor	Luther
Lapeer	L. A. Gunderson, County Engineer	Lapeer
Leelanau	Miller Biddleman, County Supt. Hwys	Leland
Lenawee	J. L. Richard, County Surveyor	Adrian
Livingston	W. J. Slavin, County Engineer	Howell
Luce	S. C. Sleeper, County Engineer	Newberry
Macomb	Leon Luke, County Engineer	Mt. Clemens
Manistee	No County Engineer	Baldwin
Marquette	K. I. Sawyer, County Supt. Hwys	Ishpeming
Mason	Louis Rohrmoser, County Supt. Hwys	Mason
Mecosta	No County Surveyor; J. Lumberg, Supt County Roads	Big Rapids
Menominee	M. B. Jensen, County Engineer	Menominee
Midland	C. A. Branson, Chrm. Board County Road Commissioners	Midland
Missaukee	No County Engineer	Lake City
Monroe	J. F. Price, County Engineer	Monroe
Montcalm	No County Surveyor	Stanton
Montmorency	Martin Rouse, County Engineer	Atlanta
Muskegon	L. H. Neilson, County Engineer	Muskegon
Newaygo	E. W. Larson, County Engineer	White Cloud
Oakland	L. V. Belknap, County Engineer	Pontiac
Oceana	No County Surveyor	Hart
Ogemaw	No County Surveyor	West Branch
Ontonagon	Thos. H. Wilcox, County Engineer	Ontonagon
Osceola	Frank McClung, County Engineer	Reed City
Otsego	Glen E. Noirot, County Supt. Highways	Gaylord
Ottawa	Carl T. Bowen, County Engineer and Surveyor	Grand Haven
Presque Isle	F. Loud, County Engineer	Rogers City
Roscommon	No County Official	Roscommon
Saginaw	H. A. Barnett, County Engineer	Saginaw
Saint Clair	Wm. W. Cox, Engineer and Mgr.	Port Huron
Saint Joseph	C. P. Chester, County Engineer	Centerville
Sanilac	Ralph A. Ulbright, County Engineer	Sandusky
Schoolcraft	John E. McCarthy, County Engr.	Manistique
Shiawasse	No County Official	Corunna
Tuscola	J. H. Schwaderer, County Surveyor	Caro
Van Buren	H. W. Ward, County Engineer	Paw Paw
Washtenaw	L. L. Townsend, County Engineer	Ann Arbor
Wayne	L. C. Smith, County Engineer	Detroit
Wexford	H. W. Holland, County Supt. Hwys	Cadillac

MINNESOTA
STATE HIGHWAY DEPARTMENT
1246 University Avenue
St. Paul

DEPARTMENT STAFF

N. W. Elsberg, Commr. of Highways.....St. Paul
J. T. Ellison, Asst. Commr. and Chief Engineer....St. Paul
N. J. Hoffman, Bridge Engineer.....St. Paul
O. L. Kipp, Construction Engineer.....St. Paul
C. L. Methven, Asst. Construction Engineer.....St. Paul
W. F. Rosenwald, Maintenance Engineer.....St. Paul
C. L. Motl, Asst. Maintenance Engineer.....St. Paul
F. C. Lang, Engineer of Tests, Inspec. and Res....St. Paul
S. C. Notestein, Chief Clerk.....St. Paul
G. G. Gladman, Engineer of Surveys and Des.....St. Paul
S. Rex Green, Engr. of Lands and Right-of-Way...St. Paul
C. C. Colwell, Office Engineer.....St. Paul

DISTRICT ENGINEERS

Geo. B. Hughes, District No. 1 (deceased).....Virginia
C. O. Harholdt, District No. 2.....Brainerd
A. O. Torgerson, District No. 3.....Detroit Lakes
Geo. C. Scales, District No. 4.....St. Paul
L. P. Zimmerman, District No. 5.....St. Paul
J. C. Robbers, District No. 6.....St. Paul
F. D. Minium, District No. 7.....Mankato
H. E. Chard, District No. 8.....St. Paul

DISTRICT MAINTENANCE ENGINEERS

Leo Cashen, Dist. Maint. Engr., Dist. No. 1.....Virginia
P. D. Mold, R. F. D. No. 1, Box 63, Dist. No. 2.....Duluth
David Rose, District No. 3.....Bemidji
A. W. Moulster, District No. 4.....Brainerd
A. M. Graves, District No. 5.....Crookston
P. F. Stary, District No. 6.....Detroit Lakes
R. D. Jorgens, District No. 7.....St. Cloud
C. A. Thompson, District No. 8.....Morris
Glenn H. Martz, District No. 9.....Hopkins
D. H. Gilchrist, District No. 10.....Willmar
M. L. Jones, District No. 11.....St. Paul Park
M. Brataas, District No. 12.....Rochester
E. V. H. Brown, District No. 13.....Owatonna
A. H. Merrill, District No. 14.....Mankato
J. F. O'Meara, District No. 16.....Windom
F. O. Nelson, District No. 15.....Marshall

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Aitkin	A. A. McPherson	Aitken
Anoka	H. E. Blewett	Anoka
Becker	Ed. Chilton	Detroit Lakes
Benton	H. G. Elletson	Foley
Beltrami	W. J. Johnson	Bemidji
Big Stone	Art Bladholm	Ortonville
Blue Earth	Clair J. Swift	Mankato
Brown	N. C. Robertson	New Ulm
Carlton	N. C. Nickerson	Carlton
Carver	L. A. Zeman	Chaska
Cass	R. A. Dahms	Walker
Chippewa	A. L. McKay	Montevideo
Chisago	A. Ingberg	Center City
Clay	H. R. Grove	Moorhead
Clearwater	W. J. Buckley	Bagley
Cook	J. E. Smith	Grand Marais
Cottonwood	C. W. Gove	Windom
Crow Wing	E. S. Rankin	Brainerd
Dakota	J. Swan	Hastings
Dodge	Geo. A. Meskal	Mantorville
Douglas	Carl Erikson	Alexandria
Faribault	Loyd Quarve	Blue Earth
Fillmore	A. F. Stegner	Preston
Freeborn	Arnold Pless	Albert Lea
Goodhue	J. A. Prior	Red Wing
Grant	W. E. Burgess	Elbow Lake
Hennepin	W. E. Duckett	Minneapolis
Houston	E. M. Paulson	Caledonia
Hubbard	A. R. Taubmann	Park Rapids
Isanti	P. M. Torell	Cambridge
Itasca	H. A. LeSueur	Grand Rapids
Jackson	W. M. Richmond	Jackson
Kanabec	W. P. Huber	Mora
Kandiyohi	H. A. Wadell	Willmar
Kittson	J. E. Dishington	Hallock
Koochiching	R. E. Martin	International Falls
LacQuiParle	Lyle Pantzke	Madison
Lake	H. C. Hanson	Two Harbors
Lake of the Woods	V. E. Crabtree	Baudette
LaSeuer	A. J. Bradshaw	LeCenter
Lincoln	Claude Zehetner	Ivanhoe
Lyon	Howard Bussard	Marshall
McLeod	Walter Baseman	Glencoe
Mahnomen	Verne Withrow	Mahnomen
Marshall	H. T. Swanson	Warren
Martin	C. N. Krosch	Fairmont
Meeker	Glenn H. Martz	Litchfield
Mille Lacs	A. Leonard	Milaca
Morrison	J. E. Viner	Little Falls
Mower	A. C. White	Austin
Murray	A. H. Engebretson	Slayton
Nicollet	L. W. Grace	St. Peter
Nobles	H. R. Bray	Worthington
Norman	Orville A. Hunt	Ada
Olmsted	A. C. Leonard	Rochester
Otter Tail	O. Skramstead	Fergus Falls
Pennington	J. A. Erickson	Thief River Falls
Pine	H. Jorgenson	Pine City
Pipestone	Elmer Keeler	Pipestone
Polk	E. H. Harding	Crookston
Pope	F. M. Shephard	Glenwood
Ramsey	P. N. Coates, County Surveyor	St. Paul
Red Lake	R. W. Tollefson	Red Lake Falls
Redwood	Richard Cook	Redwood Falls
Renville	D. H. Gilchrist	Olivia
Rice	C. W. Squires	Faribault
Rock	Julius Brown	Luverne
Roseau	V. B. Chapin	Roseau
St. Louis	S. B. Shephard, Engineer of Roads	Duluth
Scott	Donald Childs	Shakopee
Sherburne	William E. Brown	Elk River
Sibley	C. R. Patterson	Gaylord
Stearns	Glen C. Bickley, County Engineer	St. Cloud
Steele	R. W. Hosfield	Owatonna
Stevens	W. A. Hunt	Morris
Swift	L. R. Johnson	Benson
Todd	H. C. Jahnke	Long Prairie
Traverse	Helmer Hanson	Wheaton
Wabasha	J. M. Evans	Wabasha
Wadena	E. S. Ward	Wadena
Waseca	D. E. Davidson	Waseca
Washington	J. G. Merton	Stillwater
Watonwan	T. J. Buhl	St. James
Wilkin	H. E. Palmer	Breckenridge
Winona	E. P. Effertz	Winona
Wright	A. D. Jude	Buffalo
Yellow Medicine	W. B. Griebler	Granite Falls

MISSISSIPPI
STATE HIGHWAY DEPARTMENT
Jackson

COMMISSION

Brown Williams, Chairman.....Philadelphia
J. F. Thames, Commissioner.....Mendenhall
F. L. Linker, Commissioner.....Oxford

HEADQUARTERS ENGINEERS

G. A. Draper, Chief Engineer.....Jackson
Sam J. Dalton, Engineer of Maintenance.....Jackson
E. B. Cavallo, Construction Engineer.....Jackson
C. Simmons, Bridge Engineer.....Jackson
J. F. Fonville, Engineer of Plans.....Jackson
J. D. Monette, Office Engineer.....Jackson

DISTRICT ENGINEERS

C. W. F. Harper.....Jackson
W. C. McKenzie.....Yazoo City
T. C. Robbins.....Tupelo
C. E. Downing.....Oxford
J. D. Lewis.....Hattiesburg
C. F. Sherman.....McComb
J. B. Craig.....Philadelphia

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Alcorn	Willie Gant, County Surveyor	Corinth
Amite	Chas. M. Anderson, County Surveyor	Liberty
Attala	K. L. Willborn, County Surveyor	Kosciusko
Chickasaw	No County Surveyor	Houston
Choctaw	John McGaugh, County Surveyor	Ackerman
Clairborne	No County Engineer	Port Gibson
Clarke	J. D. Roberts, County Engineer	Quitman
Clay	L. W. Murphy, County Surveyor	West Point
Coahoma	No County Surveyor	Clarksdale
Copiah	W. C. Stowell, County Surveyor	Hazelhurst
Covington	J. Lacy Lee, County Surveyor	Covington
Forrest	M. F. B. Tims, County Surveyor	Hattiesburg
Franklin	E. B. Byrd, County Surveyor	Meadville
George	No County Engineer	Lucedale
Hancock	W. B. Pearson, County Surveyor	St. Louis
Harrison	No County Engineer	Gulfport
Hinds	W. B. Montgomery, County Surveyor	Jackson
Humphreys	No County Engineer	Belzoni
Isaquena	No County Engineer	Mayersville
Itawamba	J. M. Mitchell, County Surveyor	Fulton
Jackson	R. P. Delmas, County Surveyor	Pascagoula
Jasper	J. U. Crumpton, County Surveyor	Bay Springs
Jefferson	B. G. Miller, County Surveyor	Fayette
Jefferson Davis	W. G. Watts, County Surveyor	Prentiss
Jones	H. D. Sumrall, County Surveyor	Ellisville
Lafayette	Walter D. Pettes, County Surveyor	Oxford
Lamar	Hanson R. Hinton, County Surveyor	Purvis
Lauderdale	Lee Brandon, County Engineer	Meridian
Lawrence	No County Surveyor	Monticello
Leake	Roy Cox, County Surveyor	Carthage
Lee	J. T. McCarthy, County Surveyor	Tupelo
Leflore	No County Surveyor	Greenwood
Lincoln	Philip Blue, County Surveyor	Brookhaven
Lowndes	W. T. Manning, County Surveyor	Columbus
Madison	W. H. Hines, County Surveyor	Canton
Marion		Columbia
Marshall	L. H. Hall, County Surveyor	Holly Springs

Monroe—A. E. Tanner, County Engineer.....Aberdeen
Neshoba—Wm. Tingle, County Surveyor.....Philadelphia
Newton—W. P. Deen, County Surveyor.....Decatur
Pearl River—S. E. Walker, County Surveyor (H. C. Moody, County Highway Engineer.....Poplarville
Perry—T. D. Mixon, County Surveyor.....New Augusta
Pontotoc—T. Watt Jernighan, County Surveyor...Pontotoc
Prentiss—S. M. Wroten, County Surveyor.....Boonville
Rankin—Joe Wynn, County Surveyor.....Brandon
Sharkey—Summer B. Glassco, County Engr..Rolling Fork
Simpson—T. J. Ross, County Surveyor.....New Hebron
Smith—W. B. Crumpton, County Surveyor.....Raleigh
Tallahatchie—J. R. White, County Surveyor....Charleston
Tippah—A. B. Nance, County Surveyor.....Ripley
Tishomingo—L. S. Honeycutt, County Surveyor.....Iuka
Tunica—W. M. Bailey, County Surveyor.....Tunica
Union—J. T. Chum, County Surveyor.....New Albany
Warren—D. S. Hogg, County Surveyor.....Vicksburg
Walthall—No County Surveyor.....Tylertown
Washington—No County Surveyor.....Greenville
Wayne—W. R. Graham, County Surveyor.....Waynesboro
Wilkinson—No County Surveyor.....Woodville
Winston—No County Surveyor.....Louisville

MISSOURI

STATE HIGHWAY DEPARTMENT

Jefferson City

COMMISSION

Scott Wilson, Chairman, 1002 Washington St., Rice-Styx Co. .....St. Louis
Arthur T. Nelson, Vice-Chairman.....Lebanon
Dr. H. A. Buehler, Ex. Officio Member.....Rolla

LIST OF THE ADMINISTRATIVE OFFICIALS

T. H. Cutler, Chief Engineer.....Jefferson City
C. W. Brown, Assistant Chief Engineer.....Jefferson City
T. A. Wilson, Secretary.....Jefferson City
R. F. Campbell, Superintendent of Traffic....Jefferson City
C. E. Stuckey, Chief Auditor.....Jefferson City
D. B. Levi, Engineer of Construction.....Jefferson City
S. M. Rudder, Engineer of Surveys and Plans.Jefferson City
N. R. Sack, Engineer of Bridges.....Jefferson City
R. P. Cummins, Superintendent of Equipment.Jefferson City
C. P. Owens, Maintenance Engineer.....Jefferson City
F. V. Reagel, Engineer of Materials.....Jefferson City

DIVISION ENGINEERS

H. M. Brush, Div. No. 1, Rural Route No. 3.....St. Joseph
C. W. Francisco, Div. No. 2, Masonic Bldg.....Macon
Geo. L. Clark, Div. No. 3.....Hannibal
J. J. Corbett, Div. No. 4—5117 E. 31st St.....Kansas City
N. N. Ropes, Div. No. 5, Madison Hotel Bldg.Jefferson City
P. H. Daniels, Div. No. 6—327 S. Kirkwood Rd..Kirkwood
R. W. Hodson, Div. No. 7—110 E. 20th St.....Joplin
Rex M. Whitton, Div. No. 8, Atlantic and Weller Sts. .....Springfield
H. D. Griffith, Div. No. 9.....Willow Springs
A. R. Towse, Div. No. 10.....Sikeston

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Adair	John Curry, County Highway Engineer	Kirksville
Andrew	J. E. Schnitzius, County Engineer and Surveyor	Savannah
Atchison	W. E. Shandy, County Engineer and Surveyor	Phelps City
Audrain	Moss M. Edwards, County Engineer	Mexico
Barton	Reed Wilson, County Engr. and Surveyor	Lamar
Barry	Arthur Henbest, County Surveyor	Cassville
Bates	Harrison Ferry, County Surveyor	Butler
Benton	J. A. Dice, County Surveyor	Warsaw
Bollinger	Guy H. Teeters, County Surveyor	Lutesville
Boone	Hugh E. Brown, County Surveyor	Columbia
Buchanan	Chuck Torbett, County Engineer and Surveyor	St. Joseph
Butler	H. F. Scarborough, County Surveyor	Poplar Bluff
Caldwell	S. C. Rogers, County Engineer	Kingston
Callaway	W. P. Divers, County Surveyor	Fulton
Camden	G. C. Hopkins, County Engineer and Surveyor	Linn Creek
Cape Girardeau	R. R. Bedwell, County Engineer	Jackson
Carroll	E. E. Steele, County Engr. and Surv.	Carrollton
Carter	W. A. Partney, County Surveyor	Van Buren
Cass	Chas. W. Hinote, County Engineer and Surveyor	Harrisonville
Cedar	J. R. Mefford, County Engr. and Surveyor	Stockton
Chariton	Aubrey Fellows, County Engineer	Salisbury
Christian	Elmer Freeman, County Surveyor	Ozark
Clark	Harry G. Spangler, County Surveyor	Kahoka
Clay	A. J. Thompson, County Surveyor and Highway Engineer	Liberty
Clinton	A. J. St. John, County Engineer	Gower
Cole	James H. Jones, County Engineer and Surveyor	Jefferson City
Cooper	E. T. Hale, County Surveyor	Boonville
Crawford	E. A. Lindberg	Cuba
Dade	J. M. Brotherton, County Engineer	Greenfield
Dallas	Geo. S. Arnold, County Surveyor	Louisburg
Daviess	Paul W. Eastman, County Surveyor	Pattonsburg
DeKalb	Ralph Bradshaw, County Engineer and Surveyor	Maysville
Dent	Louis McSpadden, County Engr. and Surv.	Salem
Douglas	A. B. Coble, County Surveyor	Vanzant
Dunkin	V. V. Randol, County Surveyor	Kenneth
Franklin	Frank O. Fink, County Engineer	Union
Gasconade	J. C. Danuser, County Engineer and Surveyor	Hermann
Gentry	D. F. McCammon, County Surveyor	Albany
Greene	R. A. Morris, County Surveyor	Springfield
Grundy	Luther Burnett, County Engineer	Trenton
Harrison	Earl King, County Surveyor	Bethany
Henry	T. B. Parks, County Engineer	Clinton
Hickory	E. Ekloff, County Surveyor	Hermitage
Holt	John H. Peret, County Engr. and Surveyor	Oregon
Howard	Morrison Hughes, County Surveyor	Fayette
Howell	Wm. Langston	West Plains
Iron	Wm. L. Scroggin, County Engineer and Surveyor	Glover
Jackson	Leo E. Koehler, County Engineer and Surveyor	Independence
Jasper	Raymond Parker, Highway Engineer	Carthage
Jefferson	P. M. Reilly, County Engineer	Hillsboro
Johnson	C. L. Johnson, County Surveyor	Warrensburg
Knox	Andrew Gibbons, County Engineer	Edna
Laclede	Lewis Berger, County Engineer	Oakland
Lafayette	Hugh G. Rogers	Lexington
Lawrence	W. G. Hagerty	Mount Vernon
Lewis	Thomas J. Sharp, County Engineer	Monticello
Lincoln	Andy J. Brown	Troy
Linn	Ralph L. McKinney, County Engineer and Surveyor	Laclede
Livingston	H. K. Johnson, County Surveyor	Chillicothe
McDonald	S. P. Lett, County Surveyor	Pineville
Macon	Ward McDuffee	Macon
Madison	Floyd E. Gruver	Fredericktown
Maries	L. M. Eads, County Engr. and Surveyor	Vienna
Marion	W. D. Cooper, County Engineer	Palmyra
Mercer	C. S. King, County Engineer	Princeton
Miller	C. H. Reed, County Engr. and Surveyor	Gudheimer
Mississippi	L. G. Hogue, County Surveyor	Charleston
Moniteau	Edgar Strother, County Surveyor	California
Monroe	W. M. Caldwell, County Surveyor	Paris
Montgomery	R. M. Ellis, County Surveyor	New Florence
Morgan	W. R. Stevenson, County Engineer and Surveyor	Versailles
New Madrid	F. L. Steel, County Engineer and Surveyor	New Madrid
Newton	R. Y. Jones, County Surveyor	Neosho
Nodaway	Geo. S. Miller, County Engineer and Surveyor	Maryville
Oregon	Wade Heiskill, County Surveyor	Alton
Osage	P. F. Donehue, County Engineer and Surveyor	Bonnots Mill
Ozark	Wm. M. Morrison, County Engineer	Gainesville
Pemiscot	G. S. Reynolds, County Surveyor	Hayti
Perry	Edwin J. Layton, County Surveyor	Perryville
Pettis	T. O. Stanley	Sedalia
Phelps	Fred G. Perry, County Engineer and Surveyor	Rolla
Pike	J. D. Beauchamp, County Surveyor	Bowling Green
Platte	W. R. Fox	Platte City
Polk	E. H. Neuhart, County Engineer	Bolivar
Pulaski	Riley Gladden, County Engineer and Surveyor	Waynesville
Putnam	L. L. Wykoff, County Engineer and Surveyor	Unionville
Ralls	Chas. Conn	New London
Randolph	H. Holman, County Engineer and Surveyor	Moberly
Ray	W. A. Mullin, County Engr. and Surveyor	Richmond

Reynolds—James Faulkenberry ..... Centerville
Ripley—Jas. K. Langford, County Surveyor..... Doniphan
St. Charles—Alfred Riske, County Surveyor..... St. Charles
St. Clair ..... Osceola
St. Genevieve—William J. Lenz, County Surveyor. Womack
St. Francois—F. G. A. Rydeen, County Surveyor. Knob Lick
St. Louis—Roy Jablonsky, County Engineer and Surveyor ..... Clayton
Saline—C. H. Swift..... Marshall
Schuyler—Geo. M. Grist, County Engineer and Surveyor ..... Lancaster
Scotland—J. L. Sanders, County Surveyor..... Memphis
Scott—R. L. Harrison, Highway Engineer..... Benton
Shannon—T. J. Humphrey, County Engineer and Surveyor ..... Eminence
Shelby—W. B. Todd, County Engineer..... Shelbina
Stoddard—Sidney Wilson, County Engineer and Surveyor ..... Bloomfield
Stone—A. N. Peters, Highway Engineer..... Crane
Sullivan—E. L. Calfee, City Engineer..... Milan
Taney—Norval D. Wallace, County Surveyor..... Forsyth
Texas—W. T. Sutton, County Surveyor..... Cabool
Vernon—John W. Clark, County Engineer..... Nevada
Warren—Ben. F. Frick..... Warrenton
Washington—R. E. Hutchings, County Surveyor.... Potosi
Wayne—J. F. Carey..... Piedmont
Webster—Ben. Ward, County Surveyor..... Marshfield
Worth—Ivor Shipley, County Surveyor..... Isadora
Wright—M. H. Williams, County Surveyor..... Hartville

MONTANA
STATE HIGHWAY COMMISSION
Helena

COMMISSION

O. S. Warden, Chairman..... Great Falls
Axel Nelson ..... Sidney
Jas. H. Rowe..... Butte
W. O. Whipps, Secy. and Administrative Engr..... Helena

ENGINEERS

R. D. Rader, State Hwy. Engr..... Helena
W. O. Kivley, Office Engr..... Helena
P. G. Poore, Constr. Engr..... Helena
E. B. Donohue, Maint. Engr..... Helena
M. S. Hopkins, Field Bridge Engr..... Helena
B. J. Ornburn, Bridge Engr..... Helena
Seward Mason, Testing Engr..... Helena
J. L. Maloney, Accountant..... Helena

DIVISION ENGINEERS

M. J. Steere..... Butte
R. H. Willcomb..... Great Falls
H. C. Tilzey..... Missoula
R. J. Ephland..... Billings
Scott P. Hart..... Poplar

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Beaverhead	Geo. R. Metlen, County Surveyor	Dillon
Big Horn	Cliff A. Randall, County Surveyor	Kirby
Blaine	C. R. Noyes, County Engineer and Surveyor	Chinook
Broadwater	W. G. Kirscher, County Surveyor	Townsend
Carbon	Frank H. Bowman, County Surveyor	Red Lodge
Carter	C. P. Rochfort, County Surveyor	Elkalaka
Cascade	F. C. Bartholomew, County Surveyor	Great Falls
Chouteau	Frank J. Clark, County Surveyor	Big Sandy
Custer	W. P. Flynn, County Engineer and Surveyor	Miles City
Daniels	Haydn M. Thomas, County Surveyor	Whitetail
Dawson	Ralph C. Pierce, County Surveyor	Glendive
Deerlodge	Frank C. Moran, County Surveyor	Anaconda
Fallon	J. C. Corey, County Surveyor	Baker
Fergus	Frank Hogeland, County Surveyor	Lewiston
Flathead	George A. Fessenden, County Surveyor	Kalispell
Gallatin	S. D. Waldorf, County Surveyor	Bozeman
Garfield	Frank Martin, County Surveyor	Haxby
Glacier	T. C. Price, County Surveyor	Cut Bank
Golden Valley	J. Minnemann, County Surveyor	Barber
Granite	R. H. McCracklin, County Surveyor	Hall
Hill	Geo. F. Bowery, County Engineer and Surveyor	Havre
Jefferson	C. D. Flaherty, County Surveyor	Boulder
Judith Basin	W. F. Kruckeberg, County Surveyor	Stanford
Lake	M. J. Salzman, County Surveyor	Polson
Lewis & Clark	John D. McLeod, County Surveyor	Helena
Liberty	Oluf Rovreit, County Surveyor	Joplin
Lincoln	S. G. Ratekin, County Surveyor	Libby
McCone	Noel R. Banks	Oswego
Madison	Homer C. Bosworth, County Surveyor	Virginia City
Meagher	Wallace McArthur, County Surveyor	White Sulphur Springs
Mineral	Lee Eller, County Surveyor	St. Regis
Missoula	R. J. Hale	Missoula
Musselshell	No County Engineer	Roundup
Park	E. F. Apple, County Surveyor	Livingston
Petroleum	E. J. Parkinson, County Surveyor	Winnett
Phillips	W. H. Mann, County Surveyor	Malta
Pondera	George Ebner, County Surveyor	Valier
Powder River	F. L. Busch, County Surveyor	Broadus
Powell	No County Surveyor	Deer Lodge
Prairie	No County Surveyor	Terry
Ravalli	John W. Dowling, County Surveyor	Hamilton
Richland	George Brenne, County Surveyor	Fairview
Roosevelt	C. L. Arrivee, County Surveyor	Wolf Point
Rosebud	H. G. Young, County Surveyor	Forsyth
Sanders	Denver N. Laughlin, County Surveyor	Thompson Falls
Sheridan	Robert L. Wheeler, County Surveyor	Plentywood
Silver Bow	Hugh M. Quinn, County Engineer and Surveyor	Butte
Stillwater	Geo. A. Cardoza, County Surveyor	Columbus
Sweet Grass	Carl E. Busse, County Surveyor	Big Timber
Teton	O. Peterson, County Surveyor	Choteau
Toole	H. F. Cox, County Surveyor	Shelby
Treasurer	No County Surveyor	
Valley	M. H. Bailey, County Surveyor	Glasgow
Wheatland	Frank P. Goss, County Surveyor	Harlowton
Wibaux	No County Surveyor	Wibaux
Yellowstone	C. E. Durland, County Surveyor	Billings

NEBRASKA
DEPARTMENT OF ROADS AND IRRIGATION
State House
Lincoln

OFFICIALS AND ENGINEERS

R. L. Cochran, State Engineer..... Lincoln
A. T. Lobdell, Chief Bureau Roads and Bridges.... Lincoln
A. M. Gaddis, Construction Engineer..... Lincoln
J. G. Mason, Bridge Engineer..... Lincoln
A. C. Tilley, Maintenance Engineer..... Lincoln
L. C. Brown, Chief Mechanic..... Lincoln
M. B. Jones, Paving Engineer..... Lincoln
J. R. Farris, Purchasing Agent..... Lincoln
R. J. Boyd, Office Engineer..... Lincoln
Prof. C. M. Duff, Testing Engineer, University of Nebraska ..... Lincoln

DISTRICT ENGINEERS

F. H. Klietsch, District 1..... Lincoln
Edwin Olmstead, District 2..... Lincoln
J. B. Martin, District 3..... Norfolk
W. H. Bauman, District 4..... Grand Island
T. C. Middleswart, District 5..... Bridgeport
F. C. Smith, District 6..... McCook
C. W. Eubank, District 7..... North Platte
R. F. Weller, District 8..... Ainsworth

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Adams	C. A. Hartwell, County Surveyor	Hastings
Antelope	Roy E. Wagner, County Surveyor	Neligh
Banner	E. D. Drake, County Surveyor	Harrisburg
Blaine	Gustav Jockem, County Highway Commissioner	Brewster
Boone	F. M. Sillik, County Surveyor	Albion
Box	R. E. Knight	Alliance
Boyd	Francis Thibault, County Surveyor	Butte
Brown	L. P. Barnes, County Surveyor	Ainsworth
Buffalo	H. E. Sawyer, County Surveyor	Kearney
Burt	R. B. Cutler	Tekamah
Cass	Fred Patterson, County Surveyor	Plattsmouth
Cedar	E. L. Dimick, County Surveyor	Hartington

Chase—H. E. Athey, County Surveyor.....Imperial
Cheyenne—Chas. H. Gardner, County Surveyor.....Sidney
Clay—L. R. Rudd, County Surveyor.....Clay Center
Cuming—Raymond Bailey, County Surveyor....Westpoint
Custer—J. A. Vansant, County Engineer.....Broken Bow
Dakota—Halleck Mason, County Surveyor....Dakota City
Dawes—H. O. Mead, County Surveyor.....Chaldron
Dawson—H. M. Beatty, County Surveyor.....Lexington
Deuel—W. L. Wolfe, County Surveyor.....Chappell
Dixon—W. A. York, County Surveyor.....Ponca
Douglas—L. E. Adams, County Engineer.....Omaha
Fillmore—W. A. Biba, County Engineer.....Geneva
Frontier—C. D. Hayden, County Surveyor.....Stockville
Gage—J. O. Essam, County Highway Commissioner .....Beatrice
Garfield—H. E. Martland, County Surveyor.....Burwell
Gosper—T. J. Hartman, County Surveyor.....Elwood
Greeley—J. M. Murphy, County Surveyor.....Greeley
Hall—L. D. Hart, County Engineer.....Grand Island
Hamilton—Oscar Berggren, County Surveyor.....Aurora
Hayes—F. E. Rathbun, County Surveyor....Hayes Center
Holt—Melvin F. Norton, County Surveyor.....O'Neill
Hooker—R. C. Franke, County Surveyor.....Mullen
Howard—L. E. Larson, County Surveyor.....St. Paul
Jefferson—F. D. Harlan, County Surveyor.....Fairbury
Johnson—R. C. Gore, County Surveyor.....Tecumseh
Kearney—G. L. Godfrey, County Surveyor.....Minden
Keith—P. F. Conroy, County Surveyor.....Ogallala
Keyapaha—R. H. Hollenbeck, County Surveyor.Springview
Lancaster—Arthur H. Edgren, County Surveyor...Lincoln
Lincoln—P. G. Meyer, County Engineer and Surveyor .....North Platte
McPherson—A. M. Wright, County Superintendent of Highways.....Tryon
Madison—H. H. Tracey, County Surveyor.....Madison
Merrick—Raymond B. Mesner, County Surveyor .....Central City
Morrill—W. F. Chaloupka, County Surveyor....Bridgeport
Nance—C. L. Abbott, County Surveyor.....Fullerton
Nemaha—Thomas Daugherty, County Surveyor....Auburn
Nuckolls—Sidney R. Butler, County Surveyor.....Nelson
Otoe—Charles A. Shannon, County Surveyor.Nebraska City
Pawnee—O. D. Howe, County Surveyor.....Pawnee City
Phelps—Geo. M. Berquist, County Surveyor.....Holdrege
Platte—L. F. Gottschalk, County Surveyor.....Columbus
Polk—W. A. Cornish, County Surveyor.....Osceola
Red Willow—P. M. Bell, County Engineer and Surveyor .....McCook
Richardson—B. C. Dale, County Engineer.....Falls City
Saline—H. A. Davis, County Surveyor.....Wilber
Saunders—Frank E. Tracy, County Engineer and Surveyor .....Wahoo
Scotts Bluff—A. B. McCaskey, County Surveyor....Gering
Seward—Lee M. Nelson.....Seward
Sheridan—Forest Coon, County Surveyor.....Rushville
Sherman—E. B. Corning, County Surveyor.....Loup City
Thayer—A. B. Thompson, County Surveyor.....Hebron
Thurston—B. H. Lynch, County Surveyor.....Pender
Valley—Rollin C. Ayres, County Surveyor.....Ord
Wayne—Robert H. Jones, County Surveyor.....Wayne
Webster—George H. Overing, County Surveyor.Red Cloud
Wheeler—John Nelson, County Engineer and Surveyor .....Bartlett
York—D. W. Hughes, County Surveyor.....York

NEVADA
DEPARTMENT OF HIGHWAYS
Carson City

BOARD OF DIRECTORS

Gov. F. B. Balzar, Chairman.....Carson City
Ed. C. Peterson, State Controller.....Carson City
Gray Mashburn, Attorney-General.....Carson City

DEPARTMENT STAFF

S. C. Durkee, State Highway Engineer.....Carson City
H. D. Mills, Assistant State Highway Engineer.Carson City
W. T. Holcomb, Office Engineer.....Carson City
E. C. Pohl, Chief Accountant.....Carson City
Geo. R. Egan, Engineer of Design.....Carson City
Dale P. Pruett, Right of Way Engineer.....Carson City
A. Berning, Jr., Field Engineer.....Carson City
F. H. Morrison, Testing Engineer.....Carson City
Paul Rawls, Locating Engineer.....Carson City
J. P. Rawson, Equipment Superintendent.....Carson City

DIVISION ENGINEERS

C. C. Boyer.....Las Vegas
Art Loforth, Box 2051.....Reno
Waite Bruce .....Elko
F. H. Depp.....East Ely
J. C. Rodder.....Tonopah

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Churchill	C. G. Rogers	Fallon
Clark	Bud S. Barrett, County Road Supervisor	Las Vegas
Elko	Wm. Settelmeyer, County Surveyor	Elko
Esmeralda	E. S. Giles, County Surveyor	Goldfield
Humboldt	Frank O'Leary, County Surveyor	Winnemucca
Lincoln	Frank Walker, County Surveyor	Pioche
Mineral	L. B. Spencer, County Surveyor	Hawthorne
Nye	C. A. Liddell, County Surveyor	Tonopah
Ormsby	No County Surveyor	Carson City
Pershing	J. A. Rummer, County Surveyor	Lovelock
Washoe	D. H. Updike, County Engineer	Reno

NEW HAMPSHIRE
STATE HIGHWAY DEPARTMENT
State House
Concord

OFFICIALS AND ENGINEERS

F. E. Everett, Commissioner.....Concord
C. P. Riford, Construction Engineer.....Concord
J. W. Childs, Bridge Engineer.....Concord
L. F. Johnson, Maintenance Engineer.....Concord
D. H. Dickinson, Chief Engineer.....Concord
Richard Brown, Supervisor of Equipment.....Concord
M. C. Knapp, Chief Draftsman.....Concord
J. McCormick, Testing Engineer.....Concord

DISTRICT ENGINEERS

H. A. Nay, District No. 1.....Lancaster
C. M. Brooks, District No. 2, Rm. 15, Opera Block.Littleton
H. L. Smith, District No. 3.....Lakeport
F. A. Brown, District No. 4, Box 208.....Lebanon
F. W. Brown, District No. 5, School St.....Concord
O. M. James, District No. 6.....Norwood Narrows
W. A. Grover, District No. 7—99 Bow St.....Portsmouth
F. F. Hargraves, District No. 8—1008 Elm St...Manchester
A. E. White, District No. 9, Bennett Block.....Keene

NEW JERSEY
STATE HIGHWAY DEPARTMENT
Broad Street Bank Building
Trenton

COMMISSION

Arthur F. Foran, Chairman.....Flemington

DEPARTMENT STAFF

Maj. W. G. Sloan, State Highway Engineer.....Trenton
Col. H. W. Hudson, Assistant State Highway Engineer .....Trenton
A. Lee Grover, Secretary to Commission and Chief Clerk .....Trenton
Marven L. Howell, Chief Auditor and Accountant..Trenton
R. W. Wildblood, Purchase Clerk.....Trenton
C. F. Bedwell, Construction Engineer.....Trenton
Morris Goodkind, Bridge Engineer.....Trenton
H. W. Giffin, Engineer, Survey and Plans.....Trenton
E. T. Osborn, Engineer Grade Crossing Projects...Trenton
R. A. Meeker, Contractors' Qualification Officer....Trenton
A. W. Muir, Superintendent of Maintenance.....Trenton
Fred D. Woodruff, Assistant Supt. Maintenance....Trenton
Jacob Hagin, Superintendent Plant and Equipment.Trenton
R. B. Cage, Chemical Engineer.....Trenton
Fred H. Baumann, Testing Engineer.....Trenton
Walter A. Johnson, Testing Engineer.....Trenton
C. A. Burn, Northern District Engineer.....Trenton
H. D. Robbins, Southern District Engineer.....Trenton

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Atlantic	Alexander H. Nelson, County Engr.	Atlantic City
Bergen	R. A. Hartam, County Engineer	Ridgewood

Burlington—Henry B. Smith, County Engr...Mount Holly
Camden—B. M. Schmucker, County Engineer.....Camden
Cape Bay—Rolland A. Sharp, County Engineer..
.....Cape May Court House
Cumberland—Walter M. Sharp, County Engr....Bridgeton
Essex—E. F. Martin, Acting Town Engineer....Montclair
Gloucester—Wm. C. Cattel, County Engineer...Woodbury
Hudson—F. K. Radigan, County Engineer.....Jersey City
Hunterdon—Walter E. Roberts, County Engr..Flemington
Mercer—Harry F. Harris, County Engineer.....Trenton
Middlesex—C. A. Sheridan, Boro Engineer.....Carteret
Middlesex—Geo. R. Merrill, County Engineer..Woodbridge
Monmouth—Geo. K. Allen, Jr., County Engineer.Red Bank
Morris—Winfield Hopkins, County Engineer...Morristown
Ocean—H. C. Shinn, County Engineer.....Lakewood
Passaic—Garwood Ferguson, County Engineer....Paterson
Salem—Howard B. Keasbey, County Engineer.....Salem
Somerset—Oscar Smith, Jr., County Engineer...Somerville
Sussex—Harvey Snook, County Engineer.....Newton
Union—R. C. Collins, County Engineer.....Elizabeth
Warren—Harry W. Vetter, County Engineer.....Belvidere
Warren—H. W. Mixell, Town Engineer.....Phillipsburg

NEW MEXICO
STATE HIGHWAY DEPARTMENT
Santa Fe

COMMISSION

Frank Butt, President.....Albuquerque
Felipe Sanchezy Baca, Secretary.....Tucumcari

DEPARTMENT STAFF

G. D. Macy, State Highway Engineer.....Santa Fe
N. W. McCluskey, Assistant State Highway Engr.Santa Fe
E. B. Van de Groyn, Bridge Engineer.....Santa Fe
Frank Horn, Superintendent of Equipment.....Santa Fe
L. C. Campbell, Materials Engineer.....Las Cruces
R. W. Bennett, Office Engineer.....Santa Fe
R. L. Ormsbee, Chief Clerk Auditor.....Santa Fe
E. B. Van DeGroyn, Chief Draftsman.....Santa Fe
L. C. Campbell, Testing Engineer.....Santa Fe

DISTRICT ENGINEERS

C. G. Willhoite, District No. 1.....Deming
W. R. Eccles, District No. 2.....Roswell
F. D. Hawley, District No. 3.....Los Luvas
Geo. W. Brown, District No. 4.....Springer
Guy Moyes, District No. 5.....Santa Fe

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Bernalillo	C. C. Beyer, County Surveyor	Albuquerque
Catron	S. Gutierrez, County Surveyor	Reserve
Chaves	W. A. Wilson, County Engineer	Roswell
Colfax	Geo. W. Brown	Raton
Curry	R. W. Noble, County Surveyor	Clovis
DeBaca	Chas. Foor, County Surveyor	Fort Summer
Dona Ana	Fred W. Queensbury, County Engr.	LasCruces
Eddy	J. W. Lewis, County Surveyor	Carlsbad
Grant	Wm. H. Bard, County Engineer and Surveyor	Silver City
Grant	B. G. Dwyre, County Road Supt	Silver City
Guadalupe	J. A. Baca, County Surveyor	Santa Rosa
Harding	J. Garcia, County Surveyor	Mosquero
Hidalgo	A. J. Balmforth, County Surveyor	Lordsburg
Lea	V. W. Angiel, County Surveyor	Lovington
Lincoln	A. H. Harvey, County Surveyor	Carrizozo
Luna	C. B. Morgan, County Engineer	Deming
McKinley	A. J. Gilbert, County Surveyor (J. Biava, Road Superintendent)	Gallup
Mora	Garfield Holbrook, County Surveyor	Mora
Otero	T. B. Longwell, County Surveyor	Alamogordo
Quay	J. N. Stark, County Surveyor	Tucumcari
Rio Arriba	K. A. Herron, County Surv.	Tierra Amarilla
Roosevelt	McKewn Johnstone	Portales
Sandoval	L. A. Doty, County Surveyor	Bernalillo
San Juan	Chas. F. Holly, County Engineer	Aztec
Santa Fe	C. A. Cunningham, County Surveyor	Santa Fe
Socorro	W. E. West, County Surveyor	Socorro
Taos	J. A. Burns, County Surveyor	Taos
Torrance	John Johnson, County Surveyor	Estancia
Union	A. C. Loveless, County Engr. and Surv.	Clayton
Valencia	Tom Davey, County Surveyor	Los Lunas

NEW YORK
DEPARTMENT OF PUBLIC WORKS
Albany

ADMINISTRATIVE DEPARTMENT

Frederick Stuart Greene, Supt. of Public Works....Albany
Thomas F. Farrell, Chief Engineer of Department of Public Works.....Albany
Jos. E. Sheary, Chief Auditor.....Albany
H. O. Schermerhorn, Assistant Chief Engineer of Public Works.....Albany
Wm. E. Hauguaard, State Architect.....Albany

DIVISION OF HIGHWAYS

Arthur W. Brandt, Commissioner of Highways.....Albany
J. J. McNulty, Supt. of Pub. Bldgs., Capitol.....Albany
E. C. Lawton, Asst. Commr. of Highways.....Albany
C. C. Ahles, Princ. Highway Office Engr.....Albany
Ira Paul, Associate Labr. Engr., 353 Broadway.....Albany

DISTRICT ENGINEERS

J. W. Holler, Division No. 1—353 Broadway.....Albany
L. D. Brownell, Division No. 2—109 N. Genesee St...Utica
Guy W. Pinck, Division No. 3, Weigh Lock Bldg..Syracuse
H. E. Smith, Div. No. 4, Barge Canal Terminal...Rochester
C. R. Waters, Division No. 5—65 Court St., State Office Building.....Buffalo
O. J. Dempster, Division No. 6—38 Broadway.....Hornell
Roy F. Hall, Division No. 7—444 Van Duzee St.Watertown
J. S. Bixby, Division No 8, Pleasant Valley Rd., P. O. Box 533.....Poughkeepsie
Frank W. Donovan, Division No. 9—71 Frederick St. .....Binghamton
J. J. Darcy, Division No. 10—122 W. Main St., Resident Engineer .....Babylon, L. I.

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Albany	Wm. R. Gordon, County Supt. Highways.	Albany
Allegany	Harry Craig, County Supt. Highwys.	Canaseraga
Broome	H. A. Williams, County Superintendent of Highways	Binghamton
Cattaraugus	W. H. Bowen, County Superintendent of Highways	Salamanca
Cayuga	G. Ball, Acting County Supt. Highways.	Auburn
Chautauqua	S. E. Fitch, County Engineer and Superintendent of Highways	Falconer
Chemung	H. T. Gage, County Supt. Highways.	Van Etten
Chenango	E. B. Pendleton, County Supt. Hghws.	Norwich
Clinton	J. J. Coffey, County Superintendent of Highways (Acting)	Plattsburg
Columbia	L. S. Bashford, County Supt. Highways.	Hudson
Cortland	W. J. Dwyer, County Supt. Highways.	Cortland
Delaware	W. J. Howland, County Supt. Highways.	Delhi
Dutchess	G. W. Krieger, Jr., County Superintendent of Highways	Poughkeepsie
Erie	G. C. Diehl, County Supt. Highways	Buffalo
Essex	A. J. Keating, County Superintendent of Highways	Elizabethtown
Franklin	Fred Wright, County Supt. Highways	Malone
Fulton	B. Z. Kasson, County Supt. Highways.	Johnstown
Genesee	W. M. Torrence, County Supt. Highways.	Batavia
Greene	R. L. Towner	Jewett
Hamilton	G. C. Wilson, County Superintendent of Highways	Indian Lake
Herkimer	A. M. Kennedy, County Superintendent of Highways	Herkimer
Jefferson	W. R. Eggleston, County Superintendent of Highways	Watertown
Lewis	L. P. M. Gaylord, County Supt. Highways.	Lowville
Livingston	G. C. Webster, County Superintendent of Highways	Conesus
Madison	L. E. Johnson, County Supt. Highwys.	Canastota
Monroe	G. C. Wright, County Supt. Highways.	Rochester
Montgomery	L. H. M. Whitney, County Superintendent of Highways	Fonda
Nassau	W. F. Starks, County Supt. Highways.	Mineola
Niagara	R. M. Rumsey, County Supt. Highways.	Lockport
Oneida	A. O'Brien, County Supt. Highways	Utica
Onondaga	R. B. Traver, County Supt. Highways.	Syracuse
Ontario	Gordon Chester, County Superintendent of Highways	Canandaigua
Orange	Walter Relyea, County Supt. Highws.	Middletown
Orleans	H. D. Waldo, County Supt. Highways.	Albion

Oswego—Mark D. Ewell, County Supt. Highways. Oswego
Otsego—V. L. Hoke, County Superintendent of Highways ..... Springfield Center
Putnam—Richard Michell, County Supt. Highwys. Brewster
Rensselaer—C. A. Roemer, County Supt. Highways... Troy
Rockland—C. T. Allison, County Superintendent of Highways ..... Stony Point
St. Lawrence—E. E. Mattis, County Supt. Highws. Messena
Saratoga—F. R. Williams, County Superintendent of Highways ..... Saratoga Springs
Schenectady—W. W. Chadsey, County Superintendent of Highways ..... Schenectady
Schoharie—L. J. Wright, County Superintendent of Highways ..... Schoharie
Schuyler—L. E. Kenyon, County Superintendent of Highways ..... Watkins Glen
Seneca—J. E. Hudson, County Supt. Highways... Romulus
Steuben—W. G. Kellogg, County Supt. Highws. Greenwood
Suffolk—A. O. Smith, County Superintendent of Highways ..... Port Jefferson
Sullivan—A. Toaspern, County Superintendent of Highways ..... Barryville
Tioga—Wm. Clay, County Supt. Highways..... Oswego
Tompkins—B. I. Vann, County Engineer..... Ithaca
Ulster—J. F. Loughran, County Superintendent of Highways ..... Kingston
Warren—B. E. Murray, County Superintendent of Highways ..... Warrensburg
Washington—O. C. Richards, County Superintendent of Highways ..... Hudson Falls
Wayne—L. R. Barnes, County Supt. Highways..... Clyde
Westchester—Jay Downer, County Superintendent of Highways ..... White Plains
Wyoming—F. Ramsey, County Supt. Highways... Warsaw
Yates—G. E. Havens, County Superintendent of Highways ..... Penn Yan

NORTH CAROLINA STATE HIGHWAY COMMISSION

Raleigh

ADMINISTRATIVE DEPARTMENT

E. B. Jeffress, Chairman ..... Raleigh
W. Z. Betts, Purchasing Agent ..... Raleigh

ENGINEERING DEPARTMENT

John D. Waldrop, State Highway Engineer ..... Raleigh
W. Vance Baise, Asst. State Highway Engineer.... Raleigh
J. W. Mills, State Construction Engineer ..... Raleigh
W. L. Craven, Senior Bridge Engineer ..... Raleigh
B. W. Davis, Supervisor of Equipment ..... Raleigh
W. E. Hawkins, Engineer of Materials and Tests... Raleigh
J. L. Morson, Chief Draftsman Roadway Dept..... Raleigh
T. B. Gunter, Chief Draftsman Bridge Dept..... Raleigh

DISTRICT ENGINEERS

Division "A"

R. R. Roper, District No. 1 ..... Edenton
E. S. Peabody, District No. 2 ..... Washington
Roy J. Hart, District No. 3 ..... New Bern
C. F. Gore, District No. 4 ..... Weldon
W. N. Spruill, District No. 5 ..... Farmville

Division "B"

F. M. Edgerton, District No. 1 ..... Goldsboro
R. V. Biberstein, District No. 2 ..... Wilmington
C. E. Brown, District No. 3 ..... Clinton
J. B. Koonce, District No. 4 ..... Sanford
J. W. Spruill, District No. 5 ..... Lumberton

Division "C"

W. H. Rogers, District No. 1 ..... Raleigh
J. H. Proctor, District No. 2 ..... Durham
J. W. Jenkins, District No. 3 ..... Graham
C. O. Lowe, District No. 4 ..... Greensboro
Z. V. Stewart, District No. 5 ..... Winston-Salem

Division "D"

T. A. Leeper, District No. 1 ..... Elkin
A. B. Gibbs, District No. 2 ..... Statesville
D. L. McRoss, District No. 3 ..... Charlotte
L. B. Peck, District No. 4 ..... Concord
T. F. Royall, District No. 5 ..... Wadesboro

Division "E"

J. H. Council, District No. 1 ..... Boone
J. A. Poteat, District No. 2 ..... Marion
W. B. Ferguson, District No. 3 ..... Asheville
E. H. Webb, District No. 4 ..... Brevard
R. H. Plemmons, District No. 5 ..... Andrews

NORTH DAKOTA STATE HIGHWAY COMMISSION

Bismarck

D. A. Vogel, State Highway Commissioner ..... Bismarck

DEPARTMENT STAFF

H. C. Frahm, Chief Engineer ..... Bismarck
H. H. Hurning, Construction Engineer ..... Bismarck
J. N. Roherty, Research Engineer ..... Bismarck
W. J. Flannigan, Maintenance Engineer ..... Bismarck
Clifford Johnson, Bridge Engineer ..... Bismarck
W. F. McGraw, Chief Draftsman ..... Bismarck
H. G. Groves, Testing Engineer ..... Bismarck
E. C. Peck, Assistant Secretary ..... Bismarck
A. L. Overbee, Office Engineer ..... Bismarck

DIVISION ENGINEERS

E. J. Thomas ..... Bismarck
V. A. Johnston ..... Dickinson
S. O. Sorkness ..... Valley City
J. P. Kennedy ..... Grand Forks
R. C. Bertie ..... Devils Lake
H. J. Donovan ..... Minot
R. A. May ..... Williston

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Adams	No County Surveyor	Hettinger
Barnes	P. M. Barnes, County Engineer	Valley City
Benson	E. J. Schmid, County Surveyor	Minnewaukan
Billings	No County Surveyor	Medora
Bottineau	G. H. Condit, County Surveyor	Bottineau
Bowman	No County Surveyor	Bowman
Burleigh	M. H. Chernich, County Surveyor	Bismarck
Burke	John Romine, County Surveyor	Bowbells
Cass	A. S. Miller, County Surveyor	Fargo
Cavalier	M. M. Darling, County Surveyor	Langdon
Dickey	E. W. Eckert, County Surveyor	Ellendale
Divide	Roy Tyson, County Surveyor	Crosby
Dunn	T. G. Saunders, County Surveyor	Manning
Eddy	No County Surveyor	New Rockford
Emmons	V. Z. Hoffart, County Surveyor	Linton
Foster	G. W. Heinmiller, City Engineer	Carrington
Golden Valley	No County Surveyor	Beach
Grand Forks	Joseph Ingram	Grand Forks
Grant	No County Surveyor	Carson
Griggs	M. A. Ueland, County Surveyor	Cooperstown
Hettinger	R. M. Van Petten, County Surveyor	Mott
Kidder	No County Surveyor	Steele
LaMoure	J. A. Whipple, County Surveyor	LaMoure
Logan	No County Surveyor	Napoleon
McHenry	Martin Solberg, County Engineer and Surveyor	Towner
McIntosh	R. C. Miles, County Surveyor	Ashley
McKenzie	R. A. May, County Surveyor	Schafer
McLean	No County Surveyor	Washburn
Mercer	C. W. Kanthack, County Surveyor	Stanton
Morton	J. L. Brenden, County Surveyor	Mandan
Mountrail	H. B. Schmidt, County Surveyor	Stanley
Nelson	A. B. Keating, County Surveyor	Lakota
Oliver	F. J. B. Kiebert, County Surveyor	Center
Pembina	Frank Hebert, County Surveyor	Cavalier
Pierce	H. J. Bardell, County Surveyor	Rugby
Ransom	John Magill, County Surveyor	Lisbon
Renville	No County Surveyor	Mohall
Rolette	E. J. Wright, County Surveyor	Rolla
Sargent	H. A. Scoville, County Surveyor	Forman
Sheridan	Everet Knutson, County Surveyor	McClusky
Stark	No County Surveyor	Dickinson
Steele	Frank Sussex, County Surveyor	Finley
Stutsman	P. W. Legler, County Surveyor	Jamestown
Towner	E. T. Judd, County Surveyor	Cando
Traill	No County Surveyor	Hillsboro
Walsh	F. S. Anderson, County Surveyor	Grafton
Ward	C. A. Truax, County Surveyor	Minot
Wells	No County Surveyor	Fessenden
Williams	H. J. Wegley, County Surveyor and Superintendent of Highways	Williston

OHIO

DIVISION OF HIGHWAYS

Ohio-Hartman Building

Columbus

ADMINISTRATIVE AND ENGINEERING

O. W. Merrill, Director of Highways.....Columbus
H. P. Chapman, Asst. Dir. and Chief Engr.....Columbus
Elmer Hilty, Chief Engineer of Construction.....Columbus
C. E. McKee, Chief Engineer of Maintenance....Columbus
J. R. Burkey, Chief Engineer of Bridges.....Columbus
E. G. Cantwell, Purchasing Agent.....Columbus
W. D. Van Ness, Auditor.....Columbus
E. L. Shelby, Secretary to Director.....Columbus

DIVISION ENGINEERS

S. D. Downing.....Lima
R. T. Wisda.....Toledo
I. R. Ault.....Ashland
W. C. Neff.....Ravenna
B. H. Frasch.....Newark
H. D. Schoonover.....Columbus
H. C. Miller.....Sidney
Luke Brannon.....Middletown
G. M. Anderson.....Chillicothe
A. W. Sherwood.....Marietta
Fred L. Biechele.....New Philadelphia
John Jaster, Jr.....Cleveland

SPECIAL ENGINEERS

C. L. Moyer, Planning Engineer.....Columbus
R. R. Litehiser, Chief Engineer of Tests, Ohio University.....Columbus
G. E. Strauss, Right of Way Engineer.....Columbus
H. E. Neal, Traffic Engineer.....Columbus
K. L. Rothermund, Federal Project Engineer....Columbus
L. R. Anspach, Assistant Chief Engineer of Construction.....Columbus
W. H. Rabe, Chief Designing Engineer of Bridges.....Columbus
W. C. Fawcett, Locating Engineer.....Columbus
Lynn Black, Supt. of Highway Patrol.....Columbus

COUNTY HIGHWAY OFFICIALS

County. Official. City.

Adams—F. Newman, County Surveyor.....West Union
Allen—J. E. Breese, County Surveyor.....Lima
Ashland—L. G. Shenberger, County Surveyor.....Ashland
Ashtabula—E. N. Luce, County Engineer.....Jefferson
Athens—J. W. Wilson, County Surveyor.....Athens
Auglaize—V. P. Killian, County Surveyor.....Wapakoneta
Belmont—A. D. Murphy, County Surveyor...St. Clairsville
Brown—N. R. Scott, County Surveyor.....Georgetown
Butler—F. W. Mammerle, County Surveyor.....Hamilton
Carroll—D. R. Blythe, County Engr. and Surv...Carrollton
Champaign—H. P. Walters, County Engr. & Surv..Urbana
Clark—E. R. Burke, County Eng. and Surv.....Springfield
Clermont—A. G. Hilland, County Surveyor.....Batavia
Clinton—Stanley Curtis, County Surveyor and Resident Engineer.....Wilmington
Columbiana—Lloyd C. Kirk, County Surveyor.....Lisbon
Coshocton—E. P. Alford, County Engr. & Surv..Coshocton
Crawford—Chas. McNeal, County Surveyor.....Bucyrus
Cuyahoga—J. O. McWilliams, County Engineer and Surveyor.....Cleveland
Drake—Pierre V. Coppess, County Surveyor....Greenville
Defiance—Carl Wahl, County Surveyor.....Defiance
Delaware—J. C. Reichelderfer, County Engineer..Delaware
Erie—H. F. Gerold, County Engr. and Surv.....Sandusky
Fairfield—R. D. Matheny, County Surveyor.....Lancaster
Fayette—F. W. Turner, County Surveyor.....Washington Court House
Franklin—C. C. Latimer, County Engineer.....Columbus
Fulton—Karl Mohr, County Surveyor.....Wauseon
Gallia—C. E. Fife, County Surveyor.....Gallipolis
Geauga—E. A. Fiedler, County Surveyor.....Chardon
Greene—W. J. Davis, County Surveyor.....Xenia
Guernsey—Harry Green, County Surveyor.....Cambridge
Hamilton—E. A. Gast, County Surveyor.....Cincinnati
Hancock—Max Stringfellow, County Surveyor.....Findlay
Hardin—Russel Harvey, County Surveyor.....Kenton
Harrison—E. L. Mills, County Surveyor.....Cadiz
Henry—Wm. H. Meyer, County Road Supt.....Napoleon
Highland—L. H. Fenner, County Surveyor.....Hillsboro
Hocking—Orla Wolfe, County Engineer.....Logan
Holmes—Karl Snyder, County Engineer and Surveyor.....Millersburg
Huron—C. H. Bishop, County Surveyor.....Norwalk
Jackson—Ed. E. Monahan, County Surveyor.....Jackson
Jefferson—Ed. W. Martin, County Surveyor...Steubenville
Knox—E. A. Mill, County Surveyor.....Mount Vernon
Lake—R. O. Burton, Highway Superintendent, Willoughby; A. B. Wilson, County Survr...Painesville
Lawrence—L. Meyers, County Surveyor.....Ironton
Licking—Earl Watkins, County Engineer.....Newark
Logan—W. A. Montgomery, County Engr....Bellefontaine
Lorain—J. W. Warden, County Surveyor.....Elyria
Lucas—Bernard G. Kesting, County Surveyor.....Toledo
Madison—E. E. Harvey, County Surveyor.....London
Mahoning—G. M. Montgomery.....Youngstown
Marion—C. H. Tozzer, County Surveyor.....Marion
Medina—Pete Hause, County Surveyor.....Medina
Meigs—Theodore Beegle, County Surveyor.....Pomeroy
Mercer—Ralph Wright, County Surveyor.....Celina
Miami—M. A. Gantz, County Surveyor.....Troy
Monroe—Frank Starkey, County Surveyor.....Woodsfield
Montgomery—V. C. Smith, County Surveyor.....Dayton
Morgan—F. C. Smith, County Surveyor....McConnelsville
Morrow—K. B. Graham, County Surveyor...Mount Gilead
Muskingum—Wm. H. Neikirk, County Surveyor.Zanesville
Noble—G. C. Smith, County Engr. and Surveyor..Caldwell
Ottawa—R. E. Fetterman, County Engineer and Surveyor.....Port Clinton
Paulding—Chas. H. Dunkin, Resident Engineer...Paulding
Perry—J. W. Taylor, County Surveyor.....New Lexington
Pickaway—J. H. Sweetman, County Surveyor and Resident Engineer.....Circlesville
Pike—M. A. Brown, County Surveyor.....Waverly
Portage—H. L. Hubbel, County Surveyor.....Ravenna
Preble—Otha Hecathorn, County Surveyor.....Eaton
Putnam—G. A. Cartwright, County Surveyor and Resident Engineer.....Ottawa
Richland—H. C. Sword, County Surveyor.....Mansfield
Ross—John Schweitzer, County Surveyor.....Chillicothe
Sandusky—J. R. Kuns, County Surveyor.....Fremont
Scioto—Arthur H. Peake, County Surveyor....Portsmouth
Seneca—J. B. Puffenberger, County Engineer and Surveyor.....Tiffin
Shelby—W. A. Looker, County Engr. and Surv.....Sidney
Stark—W. W. Shidler, County Surveyor.....Canton
Summit—H. G. Sours, County Engr. and Surv.....Akron
Trumbull—R. H. Sillitoe, County Surveyor.....Warren
Tuscarawas—G. E. Arnold, County Surv.New Philadelphia
Union—Walter Griffith, County Surveyor.....Marysville
Van Wert—D. A. Snyder, County Surveyor.....Van Wert
Vinton—James Reynold, County Surveyor.....McArthur
Warren—J. S. Van Horn, County Surveyor.....Lebanon
Washington—Guy W. Ellis, County Surveyor.....Marietta
Wayne—P. E. Glasgow, County Surveyor.....Wooster
Williams—Walter Davis, County Surveyor.....Bryan
Wood—E. F. Metzger, County Surveyor...Bowling Green
Wyandot—Wm. F. Hehr Jr., County Engr.Upper Sandusky

OKLAHOMA

STATE HIGHWAY COMMISSION

Oklahoma City

COMMISSION

H. N. Arnold, Chairman.....Buffalo
L. B. Sleman, Vice-Chairman.....Walters
L. V. Orton, Commissioner.....Pawnee
Ed McDonald, Secretary and Commr.....Oklahoma City

DEPARTMENT STAFF

Chas. L. Wilson, State Highway Engr.....Oklahoma City
Jay E. Goss, Asst. State Highway Engr....Oklahoma City
C. W. McFerron, Construction Engr.....Oklahoma City
Homer X. White, Bridge Engr.....Oklahoma City
C. G. Keiger, Maintenance Engr.....Oklahoma City
Y. E. McClendon, Purchasing Agent.....Oklahoma City
M. R. Kester, Chief Draftsman.....Oklahoma City
Carl L. Reid, Testing Engr.....Oklahoma City
H. S. Elliott, Engr. of Plans and Sur.....Oklahoma City
R. A. Keeler, Right-of-Way Engr.....Oklahoma City

DIVISION ENGINEERS

R. T. Campbell.....Oklahoma City
E. B. Bursack.....Oklahoma City
V. R. Black.....Oklahoma City
L. S. Dillingham.....Oklahoma City
J. M. Gano.....Oklahoma City
H. D. Brown.....Oklahoma City
Claude Sale.....Oklahoma City

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Adair	James Lowe	Stilwell
Alfalfa	C. H. Guernsey, County Surveyor	Cherokee
Atoka	J. D. Holman, County Surveyor	Atoka
Beaver	P. R. Johnson, County Surveyor	Beaver
Beckham	J. A. Galloway, County Surveyor	Sayre
Blaine	C. W. Simonds, County Surveyor	Watonga
Bryan	L. V. Stinson, County Engineer	Durant
Caddo	Jim Carter, County Surveyor	Anadarko
Canadian	Leo Brooks, County Surveyor	El Reno
Carter	R. C. Bates, County Surveyor	Ardmore
Cherokee	W. C. Davis, County Surveyor	Tahlequah
Choctaw	R. P. Draper, County Surveyor	Hugo
Cimarron	Dorothy Huff, County Surveyor	Boise City
Cleveland	E. H. Durkee, County Surveyor	Norman
Coal	B. C. McCleary, County Engineer	Coalgate
Comanche	No county surveyor	Lawton
Cotton	S. W. Childers	Walters
Craig	Bentley Frasier, County Surveyor	Vinita
Creek	Bob Patrick, County Surveyor	Sapulpa
Delaware	C. N. Barnett, County Surveyor	Jay
Dewey	J. E. Fairchild, County Surveyor	Taloga
Ellis	C. V. Word, County Engineer	Arnett
Garfield	No county surveyor	Enid
Garvin	J. E. Marshall, County Surveyor	Pauls Valley
Grady	J. D. DuBose, County and City Engr.	Chickasha
Grant	V. E. Williamson, County Surveyor	Medford
Greer	Rex Wilson, County Surveyor	Mangum
Harmon	P. A. Little	Hollis
Harper	C. V. Word, County Engineer	Buffalo
Haskell	W. T. Stewart, County Surveyor	Stigler
Hughes	C. H. Edge, County Surveyor	Holdenville
Jackson	J. C. Chisum, County Surveyor	Altus
Jefferson	W. C. Howard, County Surveyor	Waurika
Kay	J. C. Clark, County Engr. and Surveyor	Newkirk
Kingfisher	Roy O'Neil, County Surveyor	Kingfisher
Kiowa	C. P. Wilson, County Engineer	Hobart
Latimer	E. Mark, County Surveyor	Wilburton
LeFlore	H. V. Yerby, County Surveyor	Poteau
Lincoln	George Gillian, County Surveyor	Chandler
Logan	Sid Ewing, County Engineer	Guthrie
Love	Jess Holloway, County Surveyor	Marietta
McClain	N. W. Wolford	Purcell
McCurtain	E. A. Martin, County Surveyor	Idabel
McIntosh	G. W. Mitchell, County Engineer	Eufaula
Major	J. L. McGee, County Surveyor	Fairview
Marshall	L. O. White, County Surveyor	Madill
Mayes	J. P. Day, County Surveyor	Pryor
Murray	J. E. Ballenger, County Surveyor	Sulphur
Muskogee	J. M. Brown, County Surveyor	Muskogee
Noble	S. R. Beasley, County Surveyor	Perry
Nowata	C. T. Babb, County Surveyor	Nowata
Okfuskee	C. P. Featherstone, County Surveyor	Okemah
Oklahoma	E. D. Hill, County Surveyor	Oklahoma City
Okmulgee	T. P. Paxton, County Surveyor	Okmulgee
Osage	W. M. Clark	Pawhuska
Ottawa	J. L. Speer, County Surveyor	Miami
Pawnee	Oscar Sewell, County Surveyor	Pawnee
Payne	L. A. Taylor, County Surveyor	Stillwater
Pittsburgh	E. McGoffin, County Surveyor	McAlester
Pontotoc	E. C. Herbert, County Surveyor	Ada
Pottawatomie	Clarence Farrell, County Surv.	Shawnee
Pushmataha	P. W. Andres, County Surveyor	Antlers
Roger Mills	J. B. Tracy, County Surveyor	Cheyenne
Rogers	J. S. Gibbs, County Surveyor	Clarence
Seminole	R. N. Greer, County Surveyor	Wewoka
Sequoyah	Leon Black, County Surveyor	Sallisaw
Stephens	Joe Bailey, County Surveyor	Duncan
Texas	J. A. Innis, County Engineer	Guymon
Tillman	D. E. Powell	Frederick
Tulsa	H. E. Smith, County Surveyor	Tulsa
Wagoner	H. H. Hellen, County Surveyor	Wagoner
Washington	J. O. Crane, County Surveyor	Bartlesville
Washita	Donnell Robinson, County Surveyor	Cordell
Woods	Ira Gibbs, County Surveyor	Alva
Woodward	H. D. Enersby, County Surveyor	Woodward

OREGON
STATE HIGHWAY COMMISSION
Salem

COMMISSION

Leslie M. Scott, Chairman of Commission.....Portland
Carl G. Washburne, Commissioner.....Eugene
E. B. Aldrich, Commissioner.....Pendleton

DEPARTMENT STAFF

H. B. Glaisyer, Secretary.....Salem
R. H. Baldock, State Highway Engineer.....Salem
J. N. Bishop, Maintenance Engineer.....Salem
C. B. McCullough, State Bridge Engineer.....Salem
H. G. Smith, Construction Engineer.....Salem
S. H. Probert, Office Engineer.....Salem
G. S. Paxson, Assistant Bridge Engineer.....Salem
W. A. Reeves, Office Bridge Engineer.....Salem
E. A. Skelley, Chief Draftsman.....Salem
N. M. Finkbiner, Testing Engineer.....Salem
Oscar Cutler, Assistant Office Engineer.....Salem

DIVISION ENGINEERS

W. E. Chandler, Division Engineer No. 1.....Salem
E. A. Collier, Division Engineer No. 2.....Roseburg
K. D. Lytle, Division Engineer No. 3.....Bend
W. C. Williams, Division Engineer No. 4.....LaGrande

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Baker	R. W. Leep, County Engineer	Baker
Benton	W. C. Galloway, County Roadmaster	Corvallis
Clackamas	D. J. Sage, County Engineer; W. Gorbett, Roadmaster	Oregon City
Clatsop	A. F. Danielson, County Engineer	Astoria
Columbia	L. R. Chandler, County Engineer	St. Helens
Coos	Wm. C. Lehman, County Engineer	Coquille
Crook	T. A. Rice, County Engineer	Redmond
Curry	Chas. Fitzhugh, County Engineer	Sixes
Deschutes	R. B. Gould, County Engineer	Bend
Douglas	F. C. Frear, County Roadmaster	Roseburg
Gilliam	H. Tamblyn, County Engineer	Heppner
Grant	L. E. Lucas, County Engineer	John Day
Harney	J. J. Walsh, County Engineer	Burns
Hood River	C. M. Hurlburt, County Engr.	Hood River
Jackson	P. B. Rynning, County Engr. and Surv.	Medford
Jefferson	T. A. Rice, County Engineer	Redmond
Josephine	J. G. Bromley, County Engineer	Grants Pass
Klamath	Jos. Jenson, County Engineer	Klamath Falls
Lake	B. J. Crowley, Resident Engineer	Lakeview
Lane	P. M. Morse, County Engineer	Eugene
Lincoln	H. M. Teel, County Engineer	Toledo
Linn	S. W. Klahn, County Engineer	Albany
Malheur	J. E. Johnson, County Engineer	Vale
Marion	H. S. Swart, County Engineer	Salem
Morrow	H. Tamblyn, County Engineer	Heppner
Multnomah	G. W. Buck, County Roadmaster	Portland
Polk	W. W. Larson, County Engineer	Dallas
Sherman	H. S. Wall, County Engineer	Wasco
Tillamook	W. S. Coates, County Engineer	Tillamook
Umatilla	No county engineer	Pendleton
Union	S. B. Morgan, County Roadmaster	LaGrande
Wallowa	J. D. Walker, County Engineer	Enterprise
Wasco	Christ Fauerso, County Roadmaster	The Dalles
Washington	J. W. Barney, County Engineer	Hillsboro
Yamhill	H. W. Herring, Co. Engr. and Surv.	McMinnville

PENNSYLVANIA
DEPARTMENT OF HIGHWAYS
State Capitol
Harrisburg

DEPARTMENT STAFF

S. S. Lewis, Secretary of Highways.....York
Samuel Eckels, Chief Engineer.....Camp Hill
W. D. Meyers, Asst. Chief Engineer.....Harrisburg
H. W. Fry, Exec. Secy. in Charge of Personnel..Harrisburg
H. S. Mattimore, Engineer of Tests.....Harrisburg
H. G. Van Riper, Township Engineer.....Carlisle
E. E. Brandow, Engineer of Bridges.....Harrisburg
F. D. Cooner, Engineer of Grade Crossing Elimination .....Camp Hill
Geo. Elsenhans, Chief Draftsman.....Camp Hill
H. K. Craig, Cost Engineer.....Harrisburg
Thos. D. Frye, Office Dir. and Comptroller.....Harrisburg
A. E. Keeley, Asst. Engr. (Asst. to Chief Engr.).Harrisburg
E. T. Baker, Asst. to Asst. Chief Engr.....Harrisburg
A. L. Dittmar, Asst. Engr. (Asst. to Asst. Chief Engr.) .....Harrisburg
C. C. Albright, Asst. Engr. (Plans).....Harrisburg
R. W. Kemmerer, Asst. Chief Draftsman.....Harrisburg
C. D. Felton, Asst. Engr. (Asst. to Twp. Engr.).Harrisburg

C. G. A. Schmidt, Asst. Equipt. Engr.....Harrisburg
Robert E. Kissinger, Spec. Asst.....York
E. R. Dietrichkeit, Asst. Comptroller.....Harrisburg
Malcolm H. Ulman, Asst. Engr. of Tests.....Harrisburg

DIVISION ENGINEERS

T. C. Frame, Div. No. 1.....Harrisburg
E. J. Kinney, Dis. No. 1.....Franklin
W. J. Carroll, Dis. No. 2.....Clearfield
J. S. Ritchey, Div. No. 2.....Harrisburg
W. A. Warrick, Dis. No. 3.....Williamsport
D. C. Stackpole, Div. No. 3.....Harrisburg
S. P. Longstreet, Dis. No. 4.....Dunmore
J. C. McCarrell, Div. No. 4.....Harrisburg
C. K. Buckius, Dis. No. 5.....Allentown
C. R. Forbes, Div. No. 5.....Harrisburg
N. A. Staples, Dis. No. 6.....Upper Darby
S. W. Jackson, Div. No. 6.....Harrisburg
H. R. Moffitt, Dis. No. 7.....Harrisburg
H. R. Wertz, Dis. No. 8.....Camp Hill
S. C. Funk, Dis. No. 9.....Hollidaysburg
E. J. Finn, Dis. No. 10.....Indiana
H. E. Kloss, Dis. No. 11.....Pittsburgh
C. A. Eichelberger, Dis. No. 12.....Uniontown

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Adams	L. H. Winebrenner, County Surveyor	Gettysburg
Allegheny	N. F. Brown, Dir. Dept. Pub. Wks.	Pittsburgh
Armstrong	D. E. Taylor, County Supervisor	Kittanning
Beaver	Michael Baker, County Surveyor	Beaver
Bedford	G. W. Cunard, County Surveyor	Bedford
Berks	L. F. Christman, Co. Engr. for Bridges	Reading
Blair	C. E. Stout, County Engineer	Hollidaysburg
Bradford	H. E. Bull, County Surveyor	Towanda
Bucks	Amos Kirk, County Surveyor	Wycombe
Butler	F. E. McQuiston, County Surveyor	Butler
Cambria	L. R. Owen, County Engineer	Edensburg
Cameron	Arch Andrews, County Surveyor	Emporium
Carbon	S. K. Evans, County Engineer	Mauch Chunk
Center	H. B. Shattuck, County Surveyor	Bellefonte
Chester	Thos. Colesworthy, County Engr.	West Chester
Clarion	Harry Kissell, County Surveyor	Clarion
Clearfield	C. A. McDonald, County Surveyor	Clearfield
Clinton	R. S. Kift, County Engineer	Lock Haven
Columbia	Boyd Trescott, County Surveyor	Bloomsburg
Crawford	Karl Miller, County Supt. Hwys.	Meadville
Cumberland	C. A. Bryan, County Surveyor	Carlisle
Delaware	George Wright, County Engineer	Media
Elk	C. Keelor Gifford, County Surveyor	Ridgeway
Erie	Wm. Supple, County Engineer	Erie
Fayette	E. L. Clemmer, County Surveyor	Uniontown
Forest	D. W. Clark, County Surveyor	Tioesta
Franklin	J. H. Atherton, County Surveyor	Chambersburg
Greene	B. T. Dinsmore, Co. Engr. & Surv.	Waynesburg
Huntingdon	A. W. Bodine, County Surveyor	Huntingdon
Indiana	G. T. McCrea, County Engr. and Surv.	Indiana
Jefferson	Wm. H. Arthurs, County Surveyor	Brookville
Junita	J. F. Patterson, County Surveyor	Mifflintown
Lackawanna	Francis Stone, Co. Engr. & Surv.	Scranton
Lancaster	H. H. Koser, County Surveyor	Lancaster
Lawrence	T. A. Gilkey	New Castle
Lebanon	L. Rothermel, County Surveyor	Lebanon
Lehigh	J. H. Sieger, County Surveyor	Allentown
Luzerne	Merl Breese, County Engineer	Wilkes-Barre
Lycoming	M. C. Krause, County Engineer	Williamsport
McKean	C. L. Lorah, County Supt. Hwys.	Smethport
Monroe	J. L. Westbrook, County Engineer	Stroudsburg
Montour	A. C. Bobb, County Surveyor	Danville
Northampton	H. C. Dillard, County Surveyor	Easton
Northumberland	W. J. O'Gara, County Engr.	Sunbury
Perry	J. L. L. Bucke, County Surveyor	New Bloomfield
Philadelphia	J. Vogelson, County Surveyor	Philadelphia
Pike	J. C. Westbrook, County Surveyor	Milford
Potter	W. S. Jones, County Surveyor	Cloudsport
Schuylkill	J. W. Geary, Jr., County Surveyor	Pottsville
Somerset	P. A. Shaffer	Somerset
Sullivan	W. C. Mason, County Engr. and Surv.	La Porte
Susquehanna	P. Wheaton, County Surveyor	Montrose
Tioga	E. H. Green	Wellsboro
Union	Walter Frick, County Engineer	Lewisburg
Warren	D. F. A. Wheelock, County Engineer	Warren
Washington	Geo. Chaney, County Road and Bridge Engineer	Washington
Wayne	C. E. Ferris, County Surveyor	Honesdale
Westmoreland	W. A. Wynn, County Engr.	Greensburg
Wyoming	O. S. Allen, County Surveyor	Tunkhannock
York	R. M. McKinnon, County Engr. and Surv.	York

RHODE ISLAND
STATE BOARD OF PUBLIC ROADS
State Office Building
Providence

BOARD

Abram L. Atwood, Chairman.....Providence
Benj. F. Robinson, Secretary.....Wakefield
Joseph P. Burlingame.....Lakewood
George R. Lawton.....Tiverton
Henry P. Stone.....Barrington
Geo. R. Wellington, Clerk and Chief Clerk of Motor Vehicle Dept. .....Cranston

DEPARTMENT STAFF

George H. Henderson, Chief Engineer.....Rumford
Henry C. Thierfelder, Office Engineer.....Apponaug
Frederick W. Hauck, Designing Engineer..East Providence
Daniel A. Soule, Maint. Engr. (Maint. & Eqpt.)..Providence
John V. Keily, Materials Engineer.....Pawtucket
Frederick H. Lake, Right-of-Way Engineer....Providence
Robert Jarrett, Location Engineer.....Warwick
Carlos G. Wright, Chief Draftsman.....Pawtucket
Thomas E. Whitney, Estimate Engineer.....Providence
Frederick H. Wild, Office Manager.....Pawtucket
C. Lester Woolley, Construction Engineer.....Providence
Daniel O. Cargill, Bridge Engineer.....Valley Falls
Wm. J. Sloan, Maint. Engr., Bridge Dept...East Greenwich
Thomas H. Roalf, Office Engineer.....Providence

DIVISION ENGINEERS

Willard F. Browning.....Wakefield
Louis H. Cloutier.....East Providence
Herbert H. Gardiner.....Wickford
Harry C. Paulson.....Thornton
Warren L. Smith, Jr.....Providence

SOUTH CAROLINA
STATE HIGHWAY DEPARTMENT
Columbia

COMMISSION

E. L. Culler, First Circuit.....Orangeburg
C. F. Rizer, Second Circuit.....Olar
E. S. Booth, Third Circuit.....Sumter
John C. Bethea, Fourth Circuit.....Dillon
W. P. Hamrock, Fifth Circuit.....Columbia
John T. Stevens, Sixth Circuit.....Kershaw
Chas. O. Hearon, Seventh Circuit.....Spartanburg
Zack W. Wright, Eighth Circuit.....Newberry
E. T. Heyward, Ninth Circuit.....Charleston
Ralph J. Ramer, Tenth Circuit.....Anderson
Geo. Bell Timmerman, Eleventh Circuit.....Lexington
W. H. Andrews, Twelfth Circuit.....Andrews
R. M. Dacus, Thirteenth Circuit.....Greenville
W. Fred Lightsey, Fourteenth Circuit.....Miley

OFFICIALS

Chas. O. Hearon, Chairman.....Spartanburg
John T. Stevens, Vice-Chairman.....Kershaw
Ben M. Sawyer, Chief Highway Commissioner...Columbia
Chas. H. Moorefield, State Highway Engineer....Columbia
O. P. Bourke, Secretary-Treasurer.....Columbia
Robert King, Supt. of Purchase.....Columbia

DEPARTMENT STAFF

J. M. Martin, Construction Engineer.....Columbia
W. K. Beckham, Maintenance Engineer.....Columbia
J. W. Barnwell, Bridge Engineer.....Columbia
L. C. Moltz, Office Engineer.....Columbia
H. J. Blackmon, Chief of Surveys and Plans.....Columbia
W. H. Mills, Testing Engineer.....Columbia
E. C. Black, Right-of-Way Engineer.....Columbia

DIVISION ENGINEERS

C. R. McMillan, Central Division.....Columbia
L. W. Pollard, Northeastern Division.....Florence
H. C. Jones, Southeastern Division.....Orangeburg
J. S. Williamson, Western Division.....Greenville

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Abbeville	F. B. Milford, Supervisor	Abbeville
Aiken	J. W. Woodward, Chrm. Bd. Commrs.	Aiken
Anderson	J. B. Spearman, Supervisor	Anderson
Allendale	Lawrence Youmans, Chief Comm.	Allendale

Bamberg—R. L. Kearse, Supervisor.....Bamberg
Barnwell—J. W. Patterson, Supervisor.....Barnwell
Beaufort—C. G. Luther, Chrm. Directors.....Beaufort
Berkley—R. A. Thornley, Supervisor.....Moncks Corner
Calhoun—Fletcher Senn, Supervisor.....St. Matthew
Charleston—E. D. Jervey, County Engr.....Charleston
Cherokee—E. J. Clary, Supervisor.....Gaffney
Chester—Fred Hardin, County Engr.....Chester
Chesterfield—J. A. Teal, Supervisor.....Chesterfield
Clarendon—J. F. Dickson, Supervisor.....Manning
Colleton—B. R. Ulmer, Supervisor.....Walterboro
Darlington—D. S. DuBose, Supv. and Engr.....Darlington
Dillon—G. E. Bond, Supervisor.....Dillon
Dorchester—W. B. Browning, Chrm. Directors..St. George
Edgefield—L. H. Prescott, Supervisor.....Edgefield
Fairfield—D. R. Coleman, Jr., Supervisor.....Winnsboro
Florence—B. P. Rice, Manager.....Florence
Georgetown—L. H. Sain, Chrm. Bd. Comm...Georgetown
Greenville—J. E. Means, Supervisor.....Greenville
Greenwood—E. L. Brooks, Supervisor.....Greenwood
Hampton—H. E. Gooding, Supervisor.....Hampton
Horry—H. C. Cannon, Supervisor.....Conway
Jasper—J. M. Langford, Supervisor.....Ridgeland
Kershaw—H. E. Munn, Road Supt.....Camden
Lancaster—D. M. John, Engineer.....Lancaster
Laurens—J. D. W. Watts, Supervisor.....Laurens
Lexington—T. H. Shull, Chrm. Bd. Comm.....Lexington
Marion—S. G. Miles, Chrm. Bd. Comm.....Marion
Marlboro—L. T. Parker, Supervisor.....Bennettsville
McCormick—G. H. McCain, Supervisor.....McCormick
Newberry—H. H. Ruff, Supervisor.....Newberry
Oconee—J. A. Pace, Supervisor.....Walhalla
Orangeburg—L. C. Boone, Engineer.....Orangeburg
Pickens—G. H. Hendricks, Supervisor.....Pickens
Richland—H. H. Hinnant, Supervisor.....Columbia
Saluda—T. B. Mitchell, Chrm. Bd. Comm.....Saluda
Spartanburg—H. B. Humbert, Engineer.....Spartanburg
Sumter—B. M. Oliver, Supt. of Roads.....Sumter
Union—J. V. Askew, Supervisor.....Union
Williamsburg—J. P. Frierson, Supervisor.....Kingstree
York—J. Y. Scruggs, Highway Engineer.....York

SOUTH DAKOTA
STATE HIGHWAY COMMISSION
Pierre

COMMISSION

Gov. Tom Berry, Chairman.....Pierre
E. H. McClean, Commissioner.....Pierre
N. E. Wadden, Commissioner.....Pierre
R. W. Clarke, Commissioner.....Pierre
Frank D. Kreibs, Secretary.....Pierre

ENGINEERS

Gardner Gantz, Highway Engineer.....Pierre
Thor Soleglad, Assistant Engineer.....Pierre
Emery Abell, Office Engineer.....Pierre
W. M. Danielson, Plans Engineer.....Pierre
C. J. Loomer, Engr. of Tests.....Pierre
W. N. Lovejoy, Bituminous Engr.....Pierre
Charles Trimmer, Maint. Engr.....Pierre

DISTRICT ENGINEERS

J. F. Jacobs, Dis. Engr.....Aberdeen
F. H. Schrader, Dis. Engr.....Huron
W. B. Mulligan, Dis. Engr.....Mitchell
H. W. Zolper, Dis. Engr.....Pierre
C. E. Smith, Dis. Engr.....Rapid City

COUNTY HIGHWAY OFFICIALS

County. Official. City.

Aurora—E. Burrington, Co. Supt. Highws.....Plankinton
Beadle—H. M. Pierce, Co. Supt. Highws.....Huron
Bennett—No County Supt. Highways.....Martin
Bon Homme—H. D. Posey, Co. Supt. Highws.....Tyndall
Brookings—H. Negstad, Co. Supt. Highws.....Brookings
Brown—W. B. Van Winkle, Co. Supt. Highws....Aberdeen
Brule—Wm. Clements, Co. Supt. Highws.....Chamberlain
Buffalo—Dell Menzie, Co. Supt. Highws.....Gannvalley
Butte—V. F. Matter, Co. Supt. Highws.....Bellefourche
Campbell—J. J. Sener, Supt. Highws.....Lake Andes
Charles Mix—R. C. Gill, Co. Supt. Highws....Lake Andes
Clark—J. D. Chance, Co. Supt. Highws.....Clark
Clay—C. J. Johnson, Co. Supt. Highws.....Vermilion
Codington—D. J. Slawson, Co. Supt. Highws...Watertown
Corson—R. A. Moore, Co. Supt. Highws.....McIntosh
Custer—C. M. Endicott, Co. Supt. Highws.....Custer
Davison—J. B. Shackelton, Co. Supt. Highws.....Mitchell
Day—Wesley Kading, Co. Supt. Highws.....Webster
Deuel—C. L. Johnson, Co. Supt. Highws.....Clear Lake
Dewey—M. J. Mathews, Co. Supt. Highws...Timber Lake
Douglas—Arthur Hargreaves, Co. Supt. Highws...Armour
Edmunds—M. L. Blank, Co. Supt. Highws.....Ipswich
Fall River—L. E. Craft, Co. Supt. Highws.....Hot Springs
Faulk—R. H. Burrell, Co. Supt. Highws.....Faulkton
Grant—O. E. Anderson, Co. Supt. Highws.....Milbank
Gregory—I. L. Hewitt, Co. Supt. Highws.....Burke
Haakon—No Co. Supt. Highways.....Philip
Hamlin—P. L. Johnson, Co. Supt. Highws.....Hayti
Hand—Wm. Sligo, Co. Supt. Highws.....Miller
Harding—J. E. Griggs, Co. Supt. Highws.....Buffalo
Hughes—D. W. Chesley, Co. Supt. Highws.....Pierre
Hutchinson—B. J. Brown, Co. Supt. Highws.....Olivet
Hyde—Frank Parker, Co. Supt. Highws.....Highmore
Jackson—F. H. Kelling, Co. Supt. Highws.....Kadoka
Jerauld—.F E. Houghland, Co. Supt. Highws.
.....Wessington Springs
Jones—C. O. Swift, County Supt. Highws.....Murdo
Kingsbury—E. L. Rice, Co. Supt. Highws.....DeSmet
Lake—John Pulford, County Supt. Highws.....Madison
Lawrence—G. B. Lawler, County Supt. Highws..Deadwood
Lincoln—E. J. Straw, County Supt. Highws.....Canton
Lyman—Wm. Stolley, County Supt. Highws.....Kennebec
Manson—W. C. McMaster, County Supt. Highws.
.....Alexandria
McCook—C. F. Halladay, County Supt. Highws....Salem
McPherson—Gottfried Neuharth, County Supt. Highws.....Leola
Marshall—J. B. Carver, County Supt. Highws.....Britton
Meade—L. P. Tarum, County Supt. Highws.....Sturgis
Mellette—No Co. Supt. Highws.....White River
Miner—H. V. Lawler, County Supt. Highws.....Howard
Minnehaha—L. E. Vercoe, County Supt. Highws.
.....Sioux Falls
Moody—Louis Lorentson, County Supt. Highws.
.....Flandreau
Pennington—D. Rounds, County Supt. Highws..Rapid City
Perkins—R. L. Henry, County Supt. Highws.....Bison
Potter—Carl Siberz, County Supt. Highws.....Gettysburg
Roberts—E. Wilson, County Supt. Highws.....Sisseton
Sanborn—A. F. Kuborn, County Supt. Highws..Woonsocket
Spink—B. E. Lovejoy, City & County Engr....Redfield
Stanley—No Co. Supt. Highws.....Fort Pierre
Sulley—F. W. Johnson, County Supt. Highws.....Onida
Tripp—Emert Mann, County Supt. Highws.....Winner
Turner—G. R. Pasco, County Supt. Highws.....Parker
Union—H. R. Joy, County Supt. Highws.....Elk Point
Walworth—F. E. Gehrki, County Supt. Highws....Selby
Yankton—F. W. Smith, County Supt. Highws....Yankton
Ziebach—F. H. Davis, County Supt. Highws.....Dupree

TENNESSEE
DEPARTMENT OF HIGHWAYS AND PUBLIC WORKS
Memorial Building
Nashville

OFFICIALS AND ENGINEERS

F. W. Webster, Commissioner.....Nashville
O. F. Goetz, State Highway Engr.....Nashville
D. W. Moulton, State Maint. Engr.....Nashville
E. M. Turner, State Construction Engr.....Nashville
J. E. Moreland, Asst. State Constr. Engr.....Nashville
Wm. S. Whitman, Acting Office Engr.....Nashville
G. V. Elmore, Asst. Maint. Engr.....Nashville
G. H. Briley, Chief Accountant.....Nashville
L. M. Bare, Asst. Engr.....Nashville

DIVISION ENGINEERS

Briggs Smith, Div. No. 1.....Knoxville
R. P. Clift, Div. No. 2.....Chattanooga
R. J. Love, Div. No. 3.....Nashville
T. C. McEwen, Div. No. 4.....Jackson
S. D. Stringfellow, Plans Division.....Nashville
L. W. Erickson, Bridge Division.....Nashville
E. W. Bauman, Testing Division.....Nashville
James Payne, Equipment Division.....Nashville

DISTRICT MAINTENANCE ENGINEERS

First Division

W. T. Brooks .....Morristown
Sam Godsey .....Harriman
Ray Griffiths .....Knoxville

G. W. Prater ..... Newport
Chas. E. Pack ..... Lafollette
John Caldwell ..... Johnson City

Second Division

L. A. Allen ..... Cookeville
H. M. Willis ..... Tullahoma
S. N. McPherson ..... Dunlap
C. F. Rich ..... Lewisburg
J. R. Murphy ..... Crossville
L. W. Hope ..... Chattanooga

Third Division

C. N. Glover ..... Murfreesboro
W. F. Hagerty ..... Gallatin
T. O. Perkins ..... Waverly
A. E. Rush ..... Clarkesville
Clay Hight ..... Columbia
R. C. Howard ..... Lawrenceburg

Fourth Division

Riley Cole ..... Troy
J. C. McCallen, Jr. ..... Jackson
S. G. Walker ..... Covington
F. P. Swaim ..... McKenzie
Z. B. Thompson ..... Selmer

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Anderson	S. I. Peters, County Engineer	Clinton
Benton	Kit Woods, County Engineer	Camden
Bledsoe	F. S. Simmons, County Supt. Highws.	Pikeville
Bradley	O. J. Larson, Pike Road Supt	Cleveland
Campbell	J. N. Miller, County Engr	Jacksboro
Carter	C. P. Toncray, County Surveyor	Elizabethton
Cheatham	W. C. R. Grier, County Engr	Ashland City
Chester	Geo. Roberts, County Engr. & Surv.	Henderson
Cocke	F. B. Jones, County Engineer	Newport
Davidson	J. C. Akers	Nashville
DeKalb	O. E. Underhill, City Engr	Smithville
Dickson	J. N. Neblett, County Engr	Charlotte
Dyer	L. O. Brayton, Consulting Engr	Dyersburg
Greene	B. F. Gregory, Co. Supt. Highws	Greenville
Hamilton	E. G. Murrell, County Engr	Chattanooga
Hardeman	County Highwy. Commissioners	Bolivar
Hardin	V. D. Phillips, County Engr	Savannah
Henderson	E. L. Fesmire, County Surveyor	Lexington
Henry	M. L. Alexander, County Engr	Paris
Hickman	L. N. Totty, County Supt. Highws	Centerville
Houston	G. G. Miles, County Engr	Erin
Humphreys	E. G. Collier, County Engr	Waverly
Jackson	No county engineer	Gainesboro
Jefferson	G. C. Zirkee, County Engr	Dandridge
Johnson	D. B. Reece, County Surveyor	Mountain City
Knox	F. L. Thomas, County Engr	Knoxville
Lake	H. E. Hamilton	Tiptonville
Lewis	Chas. Grossman, County Engr	Hohenwald
Madison	C. E. Campbell, County Supt. Highws.	Jackson
Mawry	F. B. Wilkes, Supt. of Roads	Columbia
Montgomery	J. Selsmeyer, Highway Supervisor	Clarksville
Moore	C. D. Hasty	Lynchburg
Morgan	M. O. Duncan, County Engr	Wartburg
Overton	W. P. Holt, County Surveyor	Livingston
Perry	No county engineer	Linden
Putnam	E. H. Maddux, Highway Supervisor	Cookeville
Rhea	J. W. Truex	Dayton
Roane	J. T. Staples, County Engr	Kingston
Robertson	W. M. Wynn, County Engr	Springfield
Scott	James Hugett, County Surveyor	Huntsville
Shelby	A. M. Nelson, County Engr	Memphis
Smith	W. K. Savage, Co. Hgwy. Comr	Carthage
Sullivan	E. M. Dulany, County Engr	Blountville
Sumner	J. W. Boler, County Supt. Highws	Gallatin
Unicoi	J. E. Tipton, County Engr	Erwin
Union	J. McDonald, County Surveyor	Maynardville
Van Buren	C. M. Clark, County Engr	Spencer
Washington	J. D. Dewald, County Engr	Jonesboro
White	W. I. Jarvis, Highway Supervisor	Sparta
Wilson	E. M. Baird, Highway Supervisor	Lebanon

TEXAS

STATE HIGHWAY DEPARTMENT

Austin

COMMISSION

W. R. Ely, Chairman of Commission ..... Abilene
Cone Johnson, Member of Commission ..... Austin
D. K. Martin, Member of Commission ..... San Antonio

DEPARTMENT STAFF

Gibb Gilchrist, State Highway Engr ..... Austin
Francis Luckett, Sec'y to State Highwy. Engr ..... Austin
T. H. Webb, Asst. State Highway Engr ..... Austin
G. G. Edwards, Construction Engr ..... Austin
J. B. Early, Maint. Engr ..... Austin
L. A. Fletcher, Equipment Engr ..... Austin
G. G. Wickline, Bridge Engr ..... Austin
T. J. Kelly, Designs Engr ..... Austin
W. H. Wood, Materials & Tests Engr ..... Austin
D. M. Neer, Right-of-Way Engr ..... Austin
R. J. Hank, Supt. of Aid Projects ..... Austin
Harvey Deen, General Resident Engr ..... Austin
L. G. Phares, Chief, State Highway Patrol ..... Austin
Gordon Lloyd, Chief Accountant ..... Austin
Miss Bessie Bergstrom, Chief Clerk ..... Austin

DIVISION ENGINEERS

James E. Pirie ..... Paris
M. C. Welborn, Court House ..... Fort Worth
D. M. Puckett ..... Wichita Falls
M. J. Van London ..... Amarillo
Guy R. Johnston ..... Lubbock
G. B. Finley ..... Pecos
A. F. Moursund ..... San Angelo
W. A. French ..... Abilene
E. C. Woodward ..... Waco
D. C. Greer ..... Tyler
T. E. Huffman ..... Lufkin
Jim Douglas ..... Houston
S. C. McCarty ..... Yoakum
D. E. H. Manigault ..... Austin
J. G. Rollins ..... San Antonio
Thomas W. Bailey ..... Corpus Christi
John E. Blair ..... Bryan
Clifton Rice ..... Dallas
W. D. Dockery ..... Atlanta
G. A. Bracher ..... Beaumont
J. W. Puckett ..... Pharr
M. B. Hodges ..... Del Rio
Leo Ehlinger ..... Brownwood
J. G. Lott ..... El Paso
John B. Nabers ..... Childress

COUNTY HIGHWAY ENGINEERS

County.	Official.	City.
Anderson	S. J. Treadway	Athens
Andrews	G. R. Abney	Odessa
Angelina	J. O. Booker, County Engineer	Lufkin
Archer	J. M. Isbell	Wichita Falls
Antacosta	J. V. Carnutte	Jourdanton
Austin	Herbert Schroeder	Belleville
Bailey	H. N. Roberts, Proj.	Muleshoe
Bandera	G. M. Jowers	Kerryville
Bastrop	H. R. Anderson, Proj.	Bastrop
Baylor	J. T. Brown, Proj.	Seymour
Bee	J. S. Fenner	Beeville
Bell	W. H. Garrett	Temple
Bexar	C. N. Bates	New Braunfels
Bosque	John Neubauer, Proj	Waco
Bowie & Cass	R. H. Fincher, Proj	Atlanta
Brazoria	J. R. Eeds	Brazoria
Brazos	C. C. Todd, Jr.	Bryan
Brewster	A. Buckmaier, Proj	Marfa
Brown	P. R. Huntington, Asst. Res	Brownwood
Burleson	C. C. Todd, Jr.	Bryan
Burnet	F. K. Piggott, Asst. Res	Austin
Caldwell	V. R. Schmidt	Luling
Calhoun	D. K. Shepard	Edna
Cameron	W. O. Washington, County	Brownsville
Carson	E. H. Gohmert, Proj.	Canyon
Cass	R. H. Fincher, Proj	Atlanta
Cherokee	R. R. Renshaw, Proj	Rusk
Childress	S. D. Bacon	Childress
Coke	Earl Beavers, Act. Res	Bronte
Coleman	P. R. Huntington, Asst. Res	Brownwood
Collin	C. L. Williford	Dallas
Collingsworth	C. L. Hasie	Wellington
Colorado	R. E. Schiller	Columbus
Comal	C. N. Bates, Proj	New Braunfels
Concho	G. M. Garrett	Ballinger
Cooke	R. W. Ridinger, Proj	Gainesville
Coryell	H. R. Pipkin, Proj	Waco
Cottle	J. K. LaRoe	Paducah
Crane	P. H. Caldwell, Jr	Fort Stockton
Crockett	E. P. Arneson, Location	San Antonio

Culberson—A. J. Adock....Van Horn
Dallam—C. E. Roark, Proj....Dalhart
Dallas—C. L. Williford....Dallas
Dawson—F. B. Ogle, Proj....Lamesa
Deaf Smith—E. H. Gohmert, Proj....Canyon
Delta—L. D. Cabaniss, Proj....Paris
DeWitt—W. H. Koether, Proj....Yoakum
Dickens—E. W. Mars....Spur
Dimmitt—W. C. Bushfield, Proj....Catarina
Donley—L. A. White....Pampa
Eastland—M. C. Welborn....Ft. Worth
Ector—G. R. Abney....Odessa
Ellis—A. C. Love....Ennis
El Paso—J. W. Carter....El Paso
Erath—E. L. Marek....Dublin
Falls—G. R. Burtner, Proj....Marlin
Fannin—E. C. Schwope, Proj....Bonham
Fayette—R. E. Schiller....Columbus
Fisher—S. C. Dougherty....Sweetwater
Floyd—T. B. Ingram, Proj....Floydada
Foard—B. K. Garrett, Proj....Crowell
Ford Bend—Bert Hedick, Proj....Richmond
Franklin—L. D. Cabaniss, Proj....Paris
Freestone—J. A. Waller....Buffalo
Gaines—G. R. Abney....Odessa
Garza—W. W. Hyde, Proj....Post
Gillespie—V. N. Schultz....Boerne
Goliad—J. S. Fenner....Beeville
Gonzales—L. W. Roberts, Proj....Gonzales
Gray—L. A. White....Pampa
Grayson—A. E. Drew, Asst. Res....Pittsburg
Gregg—Vance Johnson, Proj....Big Sandy
Guadalupe—Capt. A. Schlafli....Seguin
Hamilton—J. P. Kearby, Proj....Hamilton
Hansford—A. E. Dyatt....Perryton
Harris—T. C. Collier, Act. Proj....Houston
Harrison—B. I. Sage, Proj....Marshall
Hartley—C. E. Roark, Proj....Dalhart
Haskell—R. C. Rutter, Proj....Haskell
Hays—C. N. Bates, Proj....New Braunfels
Hemphill—M. E. Savage....Canadian
Henderson—S. J. Treadway....Athens
Hill—W. H. Garrett....Waco
Hood—C. B. Collom, Proj....Bluff Dale
Houston—D. K. Caldwell....Crockett
Hudspeth—J. W. Carter....El Paso
Hunt—A. J. Goode....Greenville
Hutchinson—A. E. Dyatt....Perryton
Irion—Exline Martin, Proj....Ozona
Jack—L. C. McCanlies....Perrin
Jackson—D. K. Shepard....Edna
Jasper—H. R. Pursifull....Jasper
Jeff Davis—L. E. Wood, Proj....Ft. Davis
Jefferson—W. E. Suter, Proj....Beaumont
Jim Wells—E. F. Maddox....Corpus Christi
Johnson—M. C. Welborn....Ft. Worth
Jones—R. C. Hoppe, Proj....Stamford
Karnes—J. V. Carnutte....Karnes City
Kaufman—C. L. Williford....Dallas
Kendall—T. B. Motz....Kerrville
Kerr—G. M. Jowers....Kerrville
Kimble—S. S. Posey....Junction
Kinney—D. H. Askew....Uvalde
King—E. W. Mars....Spur
Kleberg—E. F. Maddox....Corpus Christi
Knox—J. T. Brown, Proj....Seymour
Lamar—L. D. Cabaniss, Proj....Paris
Lamb—H. N. Roberts, Proj....Muleshoe
Lampasas—D. L. Hook....Lampasas
Lavaca—W. H. Koether, Proj....Yoakum
Lee—Bouldin Croftin, Proj....Giddings
Leon—J. A. Waller....Buffalo
Limestone—J. R. Ritter, Proj....Groesbeck
Lipscomb—M. E. Savage....Canadian
Live Oak—W. H. Striebeck, Jr....George West
Llano—E. B. Calvin....Fredericksburg
Lubbock—L. C. Ingram, Jr., Proj....Lubbock
Madison—A. McCormick....Madisonville
Matagorda—E. N. Gustafson....Bay City
McCulloch—E. A. Burrow, Proj....Brady
McLennan—F. B. Mason....Waco
Menard—S. S. Posey....Junction
Milam—C. B. Thames....Hearne
Mills—P. R. Huntington, Asst. Res....Brownwood
Mitchell—S. C. Dougherty....Sweetwater
Montague—Bryon Reese....Nocona
Montgomery—T. C. Collier, Act. Proj....Houston
Moore—H. W. Schmidt, Proj....Dumas
Morris—A. E. Drew, Asst. Res....Dangerfield
Motley—W. E. Bryan....Turkey
Nacogdoches—D. L. Hogan....Center
Navarro—M. L. Bowers, Asst. Res....Corsicana
Nolan—S. C. Dougherty....Sweetwater
Nueces—E. F. Maddox....Corpus Christi
Ochiltree—A. E. Dyatt....Perryton
Palo Pinto—M. C. Welborn....Ft. Worth
Panola—W. F. Hutson....Carthage
Parker—M. C. Welborn....Ft. Worth
Parmer—H. N. Roberts, Proj....Muleshoe
Pecos—P. H. Caldwell, Jr....Ft. Stockton
Polk—C. H. Kendall....Woodville
Potter—O. A. Seward, Jr....Amarillo
Presidio—A. Buchmaier, Proj....Marfa
Rains—A. J. Goode....Greenville
Randall—E. H. Gohmert, Proj....Canyon
Reagan—D. W. Hooper....Big Lake
Real—J. J. Estill....Leaky
Reeves—I. R. Titus....Pecos
Refugio—R. E. Killmer....Refugio
Roberts—M. E. Savage....Canadian
Robertson—C. B. Thames....Hearne
Runnels—G. M. Garrett....Ballinger
Rusk—E. M. Walker....Henderson
Sabine—W. D. Roseborough, Sp. Res....Lufkin
San Augustine—W. D. Roseborough, Sp. Res....Lufkin
San Jacinto—E. C. Barnard....Coldspring
San Patricio—J. S. Fenner....Beeville
San Saba—E. A. Burrow, Proj....Brady
Scurry—S. C. Dougherty....Sweetwater
Shelby—Maj. W. F. Hutson....Carthage
Sherman—H. W. Schmidt, Proj....Dumas
Smith—S. J. Treadway....Athens
Starr—S. H. Dietz, Proj....Pharr
Stonewall—R. C. Hoppe, Proj....Aspermont
Sutton—E. E. Pittman....Sonora
Tarrant—M. C. Welborn....Ft. Worth
Taylor—W. C. Connel, Proj....Abilene
Terrell—Jno. Stovell....Sanderson
Terry—R. T. Roane, Proj....Lubbock
Titus—L. D. Cabaniss, Proj....Paris
Tom Green—Earl Beavers, Act. Res....Bronte
Travis—F. K. Piggott, Asst. Res....Austin
Trinity—D. K. Caldwell....Crockett
Tyler—C. H. Kendall....Woodville
Upshur—Vance Johnson, Proj....Big Sandy
Upton—D. W. Hooper....Big Lake
Uvalde—O. P. Gill, Proj....Uvalde
Val Verde—B. B. Freeborough....Del Rio
Van Zandt—S. J. Treadway....Athens
Victoria—D. K. Shepard....Edna
Walker—D. K. Caldwell....Crockett
Ward—P. H. Caldwell, Jr....Ft. Stockton
Washington—A. McCormick....Madisonville
Webb—F. M. Percival....Laredo
Wharton—J. G. Turney, Proj....Wharton
Wheeler—M. L. Grady....Shamrock
Wichita—J. M. Isbell....Wichita Falls
Wilbarger—J. M. Isbell....Wichita Falls
Williamson—F. K. Piggott, Asst. Res....Austin
Wilson—Capt. A. Schlafli....Seguin
Wise—C. L. Williford....Dallas
Wood—J. H. Blackaller, Proj....Tyler
Young—V. O. Ellis, Act. Res....Newcastle
Zapata—F. M. Percival....Laredo

UTAH

STATE ROAD COMMISSION

Capitol Building

Salt Lake City

COMMISSION

W. J. Parker, Vice-Chairman....Salt Lake City
Preston G. Peterson, Vice-Chairman....Salt Lake City
Agnes McNeil, Secretary....Salt Lake City

DEPARTMENT STAFF

H. S. Kerr, Chief Engr....Salt Lake City
E. C. Knowlton, Asst. Engr....Salt Lake City
K. C. Wright, Asst. Engr....Salt Lake City
M. Housecroft, Chief Bridge Engr....Salt Lake City
Levi Muir, Materials Engr....Salt Lake City
W. L. Anderson, Chief Draftsman....Salt Lake City

R. W. Groo, Equipment Engr.....Salt Lake City
C. F. Dean, Chief Accountant.....Salt Lake City
M. C. Moffet, Locating Engr.....Salt Lake City

DISTRICT ENGINEERS

L. W. Beason, Dis. No. 1.....Ogden
S. L. Cate, Dis. No. 2.....Salt Lake City
J. E. Garn, Dis. No. 3.....Richfield
R. A. Gillis, Dis. No. 4.....Price
Wm. Osborn, Dis. No. 5.....Cedar City

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Beaver	W. Hurst, Co. Surv	Beaver
Box Elder	L. W. Anderson, Co. Surv	Brigham
Cache	E. Schaub, Co. Engr	Logan
Carbon	E. A. Anderson, Co. Engr. & Surv	Price
Daggett	L. Mayers, Co. Surv	Manila
Davis	F. E. Mitchell, Co. Surv	Farmington
Duchesne	J. E. L. Carey, Co. Surv	Duchesne
Emery	M. J. Murray, Co. Engr. & Surv	Castle Dale
Garfield	J. T. Partridge, Co. Surv	Panguitch
Grand	A. L. Rowell, Co. Surv	Moab
Iron	Hillman Dalley	Parowan
Juab	A. A. Miller, Co. Surv	Nephi
Kane	W. M. Cox	Kanab
Millard	F. M. Lyman, Jr., Co. Surv	Fillmore
Morgan	Jay Parkinson, Co. Surv	Morgan
Rich	C. E. Shenay, Co. Surv	Randolph
Salt Lake	J. Blickensderfer, Co. Engr. & Surv.	Salt Lake City
San Juan	Peter Allen, Co. Surv	Monticello
Sanpete	Clyde Whitlock, Co. Surv	Manti
Sevier	J. L. Ogden, Co. Surv	Richfield
Summit	C. H. Crittenden, Co. Surv	Coalville
Tooele	L. M. St. Clair, Co. Surv	Tooele
Uintah	L. Christensen, Co. Surv	Provo
Utah	Hugo Price, Co. Surv	Provo
Wasatch	M. Brown Co. Surv	Heber
Washington	W. W. Cannon, Co. Surv	St. George
Wayne	A. Osberg, Co. Surv	Loa
Weber	D. A. Scott, Co. Engr. & Surv	Ogden

VERMONT
STATE HIGHWAY DEPARTMENT
Montpelier

STATE HIGHWAY BOARD

Geo. Z. Thompson, Chairman.....Proctor
Emery A. Melendy.....South Londonderry
R. E. Farwell.....Wells River

DEPARTMENT STAFF

H. E. Sargent, Commissioner of Highways....Montpelier
A. J. Runnels, Construction Engr.....Montpelier
A. D. Bishop, Bridge Engr.....Montpelier
A. A. Doe, Office Engr.....Montpelier
M. E. Carpenter, Supv. of Equipment.....Montpelier
R. I. Rowell, Materials & Research Engr.....Montpelier
James A. Stacey, Purchasing Agent.....Montpelier
Lloyd T. Hayward, Chief Draftsman.....Montpelier
R. I. Rowell, Testing Engr.....Montpelier

DISTRICT HIGHWAY COMMISSIONERS

Geo. W. Plumb.....Bennington
P. M. Stevens.....Brattleboro
Earl R. Welch.....Rutland
C. M. Lawrence.....Ludlow
Oscar A. Harding.....Woodstock
Fred L. Dudley.....Bradford
W. W. Workman.....Essex Junct.
H. W. Marsett.....Montpelier
W. M. Gibson.....St. Johnsbury
H. L. Tilton.....St. Albans
A. B. Cobleigh.....Newport

VIRGINIA
STATE HIGHWAY COMMISSION
Richmond

COMMISSION

H. G. Shirley, Chairman.....Richmond
Wade H. Massie, Secretary.....Washington
S. W. Rawls.....Franklin
Wm. H. East.....Staunton
H. G. Gilmer.....Gate City

DEPARTMENT STAFF

C. S. Mullen, Chief Engr.....Richmond
F. D. Henley, Right of Way Engr.....Richmond
A. B. Snead, Purchasing Agent.....Richmond
A. H. Bell, Asst. Engr. Surveys & Plans.....Richmond
Shreve Clark, Asst. Engr. Tests.....Richmond
J. J. Forrer, Asst. Engr. Maint.....Richmond
W. R. Glidden, Asst. Engr. Bridges.....Richmond
C. W. Lambert, Asst. Engr. Equipt.....Richmond
G. T. Lemmon, Asst. Engr. Construction.....Richmond
C. J. Allard, Auditor.....Richmond

DISTRICT ENGINEERS

W. W. McClevy.....Bristol
S. C. Liggett.....Salem
C. B. Leech, Jr.....Lynchburg
T. F. Loughborough.....Richmond
R. P. Ellison.....Suffolk
J. H. Walker.....Fredericksburg
J. M. Hagan.....Culpeper
C. M. Moyer.....Staunton

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Accomac	S. D. Crute, Res. Engr	Accomac
Albermarle	W. M. Gose, Res. Engr	Charlotteville
Alleghany	W. C. Poston, Res. Engr	Covington
Amelia	C. H. Blake, Res. Engr	Powhatan
Amherst	E. H. Cunningham, Res. Engr	Amherst
Appomattox	S. V. Munsey, Res. Engr	Appomattox
Arlington	E. L. Micou, Res. Engr	Fairfax
Augusta	W. W. Shields, Res. Engr	Staunton
Bath	B. D. Ferrill, Res. Engr	Monterey
Bedford	W. W. Nichols, Res. Engr	Bedford
Bland	G. Felix, Res. Engr	Wytheville
Botetourt	G. D. Grey, Res. Engr	Fincastle
Brunswick	J. E. Blackley, Res. Engr	Lawrenceville
Buchanan	D. Holyfield, Res. Engr	Haysi
Buckingham	R. L. Sheppe, Res. Engr	Dillwyn
Campbell	S. V. Munsey, Res. Engr	Appomattox
Carroll	H. H. Harris, Res. Engr	Hillsville
Caroline	P. W. Snead, Res. Engr	Fredericksburg
Charles City	M. B. Hoyt, Res. Engr	Sandston
Charlotte	M. S. DeHuff, Res. Engr	Keysville
Chesterfield	E. N. Perdue, Res. Engr	Chester
Clarke	J. H. Vaughn, Res. Engr	Front Royal
Craig	O. T. Burch, Res. Engr	Salem
Culpeper	W. W. Sanders, Res. Engr	Culpeper
Cumberland	R. L. Sheppe, Res. Engr	Dillwyn
Dickenson	D. Holyfield, Res. Engr	Haysi
Dinwiddie	S. J. Mahaffey, Res. Engr	Petersburg
Elizabeth City	R. E. Duvall, Res. Engr	Newport News
Essex	C. W. Staggs, Res. Engr	Tappahannock
Fairfax	E. L. Micou, Res. Engr	Fairfax
Fauquier	F. A. Davis, Res. Engr	Warrenton
Floyd	(West of Rt. 23)) H. H. Harris	Hillsville
	(East of Rt. 23) J. D. Keeler, Jr	Christianburg
Fluvanna	D. H. Selvage, Res. Engr	Louisa
Franklin	H. L. Smith, Res. Engr	Rocky Mount
Frederick	G. P. Bozel, Res. Engr	Winchester
Giles	J. L. Sneed, Res. Engr	Pulaski
Gloucester	E. M. Wickre, Res. Engr	Saluda
Goochland	M. B. Hoyt, Res. Engr	Sandston
Grayson	L. Hines, Res. Engr	Marion
Greene	K. G. McWane, Res. Engr	Orange
Greenville	J. E. Blackley, Res. Engr	Lawrenceville
Halifax	J. W. Wyse, Res. Engr	Halifax
Hanover	W. B. Bates, Res. Engr	Ashland
Henrico	M. B. Hoyt, Res. Engr	Sandston
Henry	W. F. Smith, Res. Engr	Martinsville
Highland	B. D. Ferrill, Res. Engr	Monterey
Isle of Wight	R. I. Mount, Res. Engr	Suffolk
James City	R. E. Duvall, Res. Engr	Newport News
King and Queen	C. W. Staggs, Res. Engr	Tappahannock
King George	M. B. King, Res. Engr	King George
King William	C. W. Staggs, Res. Engr	Tappahannock
Lancaster	J. J. Cassidy, Res. Engr	Warsaw
Lee	J. R. Crill, Res. Engr	Big Stone Gap
Louisa	D. H. Selvage, Res. Engr	Louisa
Loundon	F. M. Yellot, Res. Engr	Leesburg
Lunenburg	J. V. Clark, Res. Engr	South Hill
Madison	K. G. McWane, Res. Engr	Orange
Mathews	E. M. Wickre, Res. Engr	Saluda

Mecklenburg—J. V. Clarke, Res. Engr.....South Hill
Middlesex—E. M. Wickre, Res. Engr.....Saluda
Montgomery—J. D. Keeler, Jr., Res. Engr....Christianburg
Nansemond—R. I. Mount, Res. Engr.....Suffolk
Nelson—E. H. Cunningham, Res. Engr.....Amhurst
New Kent—W. B. Bates, Res. Engr.....Ashland
Norfolk—L. E. Akers, Res. Engr.....Norfolk
Northampton—S. D. Crute, Res. Engr.....Accomac
Northumberland—J. J. Cassidy, Res. Engr.....Warsaw
Nottoway—C. H. Blake, Res. Engr.....Powhatan
Orange—K. G. McWane, Res. Engr.....Orange
Page—C. Clausen, Res. Engr.....Woodstock
Patrick—W. F. Smith, Res. Engr.....Martinsville
Pittsylvania—J. S. Carter, Res. Engr.....Chatham
Powhatan—C. H. Blake, Res. Engr.....Powhatan
Prince Edward—M. S. DeHuff, Res. Engr.....Keysville
Prince George—S. J. Mahaffey, Res. Engr....Petersburg
Prince William—E. L. Micou, Res. Engr.....Fairfax
Princess Anne—L. E. Akers, Res. Engr.....Norfolk
Pulaski—J. L. Sneed, Res. Engr.....Pulaski
Rappahannock—W. W. Sanders, Res. Engr.....Culpeper
Richmond—J. J. Cassidy, Res. Engr.....Warsaw
Roanoke—O. T. Burch, Res. Engr.....Salem
Rockbridge—H. L. Hanger, Res. Engr.....Lexington
Rockingham—P. O. Bailey, Res. Engr.....Harrisonburg
Russell—M. T. Thurston, Jr., Res. Engr.....Lebanon
Scott—H. H. Holmes, Res. Engr.....Gate City
Shenandoah—C. Clausen, Res. Engr.....Woodstock
Smyth—L. Hines, Res. Engr.....Marion
Southampton—D. A. Stover, Res. Engr.....Franklin
Spotsylvania—P. W. Snead, Res. Engr.....Fredericksburg
Stafford—M. B. King, Res. Engr.....King George
Surry—A. T. Arnold, Res. Engr.....Waverly
Sussex—A. T. Arnold, Res. Engr.....Waverly
Tazewell—C. M. Gillespie, Res. Engr.....Tazewell
Warwick—R. E. Duvall, Res. Engr.....Newport News
Washington—C. W. Kestner, Res. Engr.....Abingdon
Westmoreland—M. B. King, Res. Engr.....King George
Warren—J. H. Vaughn, Res. Engr.....Front Royal
Wise—J. R. Crill, Res. Engr.....Big Stone Gap
Wythe—G. Felix, Res. Engr.....Wytheville
York—R. E. Duvall, Res. Engr.....Newport News

WASHINGTON
STATE HIGHWAY DEPARTMENT
Olympia

STATE HIGHWAY DEPARTMENT

L. V. Murrow, Director of Highways.....Olympia
J. D. MacVicar, Office Engr.....Olympia
James A. Davis, Construction Engr.....Olympia
H. G. Porak, Engr. of Plans & Surveys.....Olympia
J. W. Hamilton, Maint. Engr.....Olympia
O. R. Elwell, Bridge Engr.....Olympia
H. W. Pierong, Right of Way Engr.....Olympia
Bailey Tremper, Engr. of Tests.....Olympia
Lynn Fullerton, Department Auditor.....Olympia

DISTRICT ENGINEERS

Geo. H. Shearer, Dis. No. 1.....Seattle
John Duff, Dis. No. 2.....Wenatchee
R. P. Newland, Dis. No. 3.....Olympia
O. R. Dinsmore, Dis. No. 4.....Vancouver
E. C. Simpson, Dis. No. 5.....Yakima
Norman Hill, Dis. No. 6.....Spokane

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Adams	W. W. Athey, Const. Engr.	Ritzville
Asotin	J. Swain, Co. Engr.	Asotin
Benton	H. J. Strandwold, Co. Engr.	Prosser
Chelan	B. B. Carter, Co. Engr.	Wenatchee
Clallan	T. F. Rixon, Co. Engr.	Port Angeles
Clark	C. Deako, Co. Engr.	Vancouver
Columbia	C. A. Winnett, Co. Engr.	Dayton
Cowlitz	F. C. Cramer, Co. Engr.	Kalama
Douglas	F. S. Thomas, Co. Engr.	Waterville
Ferry	B. O. Bendixon, Co. Engr.	Republic
Franklin	H. L. Blanton, Co. Engr.	Pasco
Garfield	G. L. Finch, Co. Engr.	Pomeroy
Grant	A. B. Humanson, Const. Engr.	Ephrata
Grays Harbor	J. H. Kirkwood, Co. Engr.	Montesano
Island	L. A. Wanamaker, Co. Engr.	Coupeville
Jefferson	W. A. Bugge, Co. Engr.	Pt. Townsend
King	T. D. Hunt, Co. Engr.	Seattle
Kitsap	No county engineer	Port Orchard
Kittitas	W. T. Bowman, Co. Engr.	Ellenburg
Klickitat	T. B. Wilson, Co. Engr.	Goldendale
Lewis	No county engineer	Chehalis
Lincoln	R. B. Shaw, Co. Engr.	Davenport
Mason	A. L. Ward, Co. Engr.	Shelton
Okanogan	M. P. McCoy, Co. Engr.	Okanogan
Pacific	R. E. Woodward, Co. Engr. & Surv.	South Bend
Pend Orielle	J. C. Stegner, Co. Engr.	Newport
Pierce	W. E. Berry, Co. Engr.	Tacoma
San Juan	W. S. Sallee, Co. Engr.	Friday Harbor
Skagit	R. E. L. Knapp, Co. Engr.	Mt. Vernon
Skamania	C. A. LaBarre, Co. Engr.	Stevenson
Snohomish	R. D. Alverson, Co. Engr.	Everett
Spokane	A. R. Scott, Co. Engr.	Spokane
Stevens	C. A. Heberling, Const. Engr.	Colville
Thurston	N. R. McKay, Co. Engr.	Olympia
Wahkiakum	G. L. Osborne, Co. Engr.	Cathlamet
Walla Walla	E. R. Smith, Co. Engr.	Walla Walla
Whatcom	J. M. Adams, Supervising Engr.	Bellingham
Whitman	W. M. Bloom, Co. Engr.	Colfax
Yakima	O. E. Brashears, Co. Engr.	Yakima

WEST VIRGINIA
STATE ROAD COMMISSION
Charleston

COMMISSION

Ernest L. Bailey, Commissioner.....Charleston

DEPARTMENT STAFF

Mortimer W. Smith, Chief Engineer.....Charleston
H. O. Wiles, Asst. Chief Engineer.....Charleston
Prof. R. P. Davis, Consulting Engr.....Morgantown
L. L. Jemison, Bridge Engr.....Charleston
Fred A. Davis, Materials & Research Engr....Morgantown
L. C. Madden, Engr. of Plans & Surveys.....Charleston
Fred A. Davis, Testing Engr.....Morgantown

DISTRICT ENGINEERS

Geo. W. McAlpin.....Charleston
C. M. Binford.....Huntington
J. M. McKinney.....Parkersburg
Frank D. McEnteer.....Clarksburg
Burr H. Simpson.....Keyser
Harry McGraw.....Moundsville
E. C. Bennett.....Weston
Paul H. Keener.....Elkins
E. L. Worthington.....Lewisburg
L. R. Taylor.....Princeton

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Barbour	A. M. Humphreys, Co. Engr.	Philippi
Berkley	C. N. Stuckey, Co. Engr.	Martinsburg
Brooke	Harry McGraw	Wellsburg
Cabell	J. M. Oliver, Co. Engr.	Huntington
Clay	J. S. Chase, Co. Engr.	Clay
Doddridge	J. M. Martin, Co. Engr.	West Union
Gilmer	S. Buderman, Co. Engr.	Glenville
Greenbrier	J. K. Monroe	Lewisburg
Harrison	Draco Dodrill, Co. Engr.	Clarksburg
Kanawha	Tom Carter, Co. Roads Supervisor	St. Albans
Lewis	M. L. B. Linger, Co. Engr.	Weston
McDowell	C. H. Paine, Road Supervisor	Welch
Marion	P. Billingslea, Co. Engr.	Fairmont
Marshall	B. W. Brown, Co. Engr.	Moundsville
Mercer	R. Bailey, Co. Engr.	Princeton
Mingo	M. P. Keadle, Co. Engr.	Williamson
Monongalia	W. S. Price, Co. Engr.	Morgantown
Nicholas	C. H. Craig	Summersville
Ohio	C. E. Kindleberger, Co. Engr.	Wheeling
Raleigh	H. M. Scott, Co. Engr.	Beckley
Ritchie	D. W. Shock, Co. Engr.	Harrisville
Summers	W. E. Trail, Co. Surv.	Hinton
Upshur	F. O. Leonard, Co. Engr.	Buckhannon
Wayne	H. O. Wiles, Co. Road Engr. & Surv.	Wayne
Wetzel	W. H. Ramp, Co. Engr.	New Martinsville
Wood	W. A. Bosco, Co. Engr.	Parkersburg
Wyoming	J. F. Koerner, Co. Engr.	Mullens

WISCONSIN
STATE HIGHWAY COMMISSION
State Office Building
Madison

COMMISSION

Wm. E. O'Brien, Chairman....Madison
Fred A. Russell, Vice-Chairman....Madison
Thos. J. Pattison, Secretary....Madison

DEPARTMENT STAFF

E. E. Parker, Acting State Highway Engr....Madison
M. W. Torkelson, Regional Planning Director....Madison
W. B. Blair, Chief Accountant....Madison
E. J. O'Meara, Traffic Engr....Madison
Chas. W. Thompson, Asst. Secretary....Madison
E. L. Roettiger, Construction Engr....Madison
L. K. Astell, Asst. Engr....Madison
M. G. Davis, Asst. Engr....Madison
Jos. Zapata, Chemist....Medison
C. H. Kirch, Bridge Engr....Madison
A. O. Olson, Asst. Bridge Engr....Madison
J. I. Grann, Asst. Bridge Engr....Madison
H. D. Blake, Principal Asst. Engr....Madison
Frank Cnare, Plan Engr....Madison
Joe Porter, Asst. Plan Engr....Madison
Wm. Hoenig, Maint. Engr....Madison
Wm. Sherlock, Asst. Maint. Engr....Madison

DIVISION ENGINEERS

D. J. Minahan, Div. No. 1....Madison
J. A. Stransky, Div. No. 2....Milwaukee
D. F. Culbertson, Div. No. 3....Green Bay
W. J. Haselton, Div. No. 4....Wisconsin Rapids
T. M. Reynolds, Div. No. 5....La Crosse
W. F. Baumgartner, Div. No. 6....Eau Claire
S. A. Koszarek, Div. No. 7....Rhinelander
G. I. Germond, Div. No. 8....Superior
Thos. W. Reilly, Div. No. 9....Lancaster

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Adams	J. A. McGregor	Friendship
Ashland	A. O. Hellrud	Ashland
Barron	J. B. Stearn	Barron
Bayfield	H. B. Curry	Washburn
Brown	G. J. Cormier	Green Bay
Buffalo	W. H. Meyers	Alma
Burnett	G. E. Malone	Webster
Calumet	J. A. Gillis	Chilton
Chippewa	W. H. Taylor	Chippewa Falls
Clark	O. J. Weyhmiller	Neillsville
Columbia	George Batty	Portage
Crawford	S. A. Larivierre	Lynxville
Dane	J. R. Caldwell	Madison
Dodge	E. C. Nitschke	Juneau
Door	R. B. Bieri	Sturgeon Bay
Douglas	C. Hanson	Superior
Dunn	H. Gunderson	Menomonie
Eau Claire	G. Osborn	Eau Claire
Florence	J. Roach	Florence
Fond du Lac	J. Bottkol	Fond du Lac
Forest	J. Adams	Crandon
Grant	H. Mink	Lancaster
Green	H. Kohn	Monroe
Green Lake	W. R. Jenkins	Green Lake
Iowa	J. E. Wedlake	Dodgeville
Iron	A. J. Lamont	Hurley
Jackson	O. H. Overlien	Black River Falls
Jefferson	H. J. Grell	Jefferson
Juneau	H. Christenson	New Lisbon
Kenosha	J. F. Herzog	Kenosha
Kewaunee	H. Griese	Kewaunee
La Crosse	F. J. Davy	La Crosse
Lafayette	H. I. Shockley	Darlington
Langlade	J. Rusch	Antigo
Lincoln	H. H. Kuehling	Merrill
Manitowoc	E. Berkedal	Manitowoc
Marathon	J. A. Clark	Wausau
Marinette	A. Eklund	Peshtigo
Marquette	H. Schmitz	Montello
Milwaukee	W. F. Cavanaugh	Milwaukee
Monroe	G. Goff	Sparta
Oconto	A. Dunton	Oconto
Oneida	H. J. Williams	Rhinelander
Outagamie	F. R. Appleton	Appleton
Ozaukee	W. J. Ubbink	Port Washington
Pepin	A. Weishapple	Durand
Pierce	H. Kennal	Ellsworth
Polk	M. Miller	Balsom Lake
Portage	T. E. Cauley	Stevens Point
Price	Wm. Jackson	Phillips
Racine	E. R. Fischer	Racine
Richland	W. V. Robinson	Richland Center
Rock	C. E. Moore	Janesville
Rusk	D. J. Summerville	Ladysmith
St. Croix	H. B. Olsen	Hammond
Sauk	W. Halbersleben	Baraboo
Sawyer	O. Treland	Hayward
Shawano	F. Sieber	Shawano
Sheboygan	A. C. Dropper	Sheboygan
Taylor	W. C. Miller	Medford
Trempealeau	W. Mason	Arcadia
Vernon	C. Hoff	Viroqua
Vilas	W. F. Hunter	Eagle River
Walworth	H. J. Peters	Elkhorn
Washburn	J. R. Allen	Spooner
Washington	Wm. Goebel	West Bend
Waukesha	C. J. Hahn	Waukesha
Waupaca	L. P. Pelishek, Engineer	Clintonville
Waushara	F. Grimm	Wautoma
Winnebago	E. M. Bird	Oshkosh
Wood	J. Lewis	Wisconsin Rapids

WYOMING
STATE HIGHWAY DEPARTMENT
Cheyenne

COMMISSION

Louis J. O'Marr, Chairman....Sheridan
R. F. Tebbett....Torrington
F. M. Mills....Rock Springs
W. S. Kimball....Casper
Ralph E. Foe....Greybull

DEPARTMENT STAFF

James B. True, Supt.-Engineer....Cheyenne
C. C. Warrington, Office Engr....Cheyenne
C. F. Seifried, Engr. of Plans....Cheyenne
W. H. Fisher, Bridge Engr....Cheyenne
I. E. Russell, Materials Engr....Cheyenne
J. E. Peirson, Equipment Engr....Cheyenne
J. E. Lloyd, Oil Engr....Cheyenne
W. E. Davis, Chief Accountant-Secretary....Cheyenne

DISTRICT ENGINEERS

J. G. Smith....Cheyenne
R. J. Templeton....Rock Springs
J. R. Phillips....Casper
R. C. Kay....Basin
Talcott Moore....Sheridan
G. D. Gorwine....Newcastle
G. W. Marks....Rawlins

COUNTY HIGHWAY OFFICIALS

County.	Official.	City.
Albany	W. E. Zipfel, County Surveyor	Laramie
Big Horn	H. C. Avery, County Engr. and Surv	Basin
Campbell	R. L. Streeter, County Surveyor	Gillette
Carbon	S. J. Sharp, County Surveyor	Rawlins
Converse	A. Urban, County Surveyor	Douglas
Crook	S. A. Hickenbottom	Sundance
Fremont	G. W. Higby, County Surveyor	Lander
Goshen	P. Rouse, County Surveyor	Torrington
Hot Springs	No county surveyor	Thermopolis
Johnson	F. Gatchell, County Surveyor	Buffalo
Laramie	L. F. Brown, County Engr. and Surv.	Cheyenne
Lincoln	P. W. Banks, County Engineer	Kemmerer
Natrona	W. H. Tolhurst, County Surveyor	Casper
Park	H. F. Bell, County Surveyor	Cody
Platte	A. B. Bartlett	Wheatland
Sheridan	E. C. Gwillim, County Engineer	Sheridan
Sweetwater	D. P. Miller	Green River
Teton	O. E. Williams, County Surveyor	Jackson
Uinta	E. C. Gradert, County Engineer	Evanston
Washakie	G. M. Donnell, County Surveyor	Worland
Weston	B. A. Howell, County Surv. and Engr.	Newcastle

DATA SECTION - - - -

Roadway and Drainage Excavation

Specifications, Illinois Division of Highways

Description.—Excavation shall consist of the removal and satisfactory disposal of all materials taken from within the right of way limits necessary for the preparation and construction of the roadbed, embankments, subgrade, shoulders, intersections, side ditches, take-off ditches, and waterways; it shall also include the grading of entrances and approaches. It shall include the removal and satisfactory disposal of all surplus and unsuitable materials encountered in the roadway; the replacement of any such unsuitable material with satisfactory material; the breaking up of all gravel, macadam, or other surfacing material, except portland cement concrete base course and pavement, which may be in place on the old roadway; and the satisfactory disposal of the same as hereinafter specified. This item does not include material obtained from borrow pits outside of the right of way limits, nor does it include excavation for sturctures.

Classification.—Excavation shall include all materials of whatever nature encountered. The classification of material will be made by the engineer as the work progresses, and the classification determined upon by the engineer for the work completed during each month will be included in the current monthly estimate. If the classification thus allowed by the engineer is not protested by the contractor in writing within fifteen (15) days after the date of payment of the estimate, the contractor agrees to waive his right to any claim to any change in classification of the work involved in such estimate.

Classification of excavation material shall be on the following basis:

Class A Excavation.—This classification shall include all materials such as clay, sand, loam, gravel, etc., which, without first being loosened by other means, can be reasonably plowed with a heavy railroad type mold board plow pulled by adequate power. It shall include mud and all other material which does not come under Class B or Class C excavation.

Class B Excavation.—This classification shall include beds or deposits of detached rocks or stones measuring more than one (1) cubic foot and less than one-half (½) cubic yard in volume; all materials such as slate, shale, conglomerate, hardpan, clay, gravel, etc., which, without first being loosened by other means, cannot be reasonably plowed with a heavy railroad type mold board plow pulled by adequate power, but which can be removed with heavy machinery without blasting, even though blasting may be resorted to in order to facilitate handling.

Class C Excavation.—This classification shall include all boulders and rock measuring one-half (½) cubic yard in volume and upwards; all solid or hard ledge rock in removing which it is necessary to resort to continuous drilling and blasting.

Construction Methods.—All grass, weeds and other vegetation shall be cut and properly disposed of before the ground is broken for excavation or before any embankments are made thereon. In general all suitable materials removed from the excavation shall be used in forming the necessary embankments, subgrade and shoulders and in such other places as may be directed. All rocks and boulders uncovered in excavation, or found in the right of way, shall be placed in embankments, provided the embankments are of such depth that these rocks or boulders can be covered with at least twelve (12) inches of earth. As far as possible, all such rocks or stones shall be placed under the shoulders and not under the surfacing.

During the excavation of the roadway, the sides of the roadbed shall be kept lower than the center, and the surface shall be maintained at all times in such condition as will insure adequate drainage. The excavation shall be conducted in such manner as will insure against removing or loosening any material outside of the required slopes, and any such material removed shall be replaced in a manner satisfactory to the engineer.

The width and grade of all approaches to intersecting roads, shall be as shown on the plans. The width of roadbed for field and private entrances shall be sixteen (16) feet, the grade not to exceed ten (10) per cent and the side slopes 1½:1. Small culverts at intersecting roads and private entrances shall preferably be built after the adjacent ditches have been brought to the established grade.

Where excavation is in rock, it shall extend to the subgrade elevation shown on the plans, and if rock below this elevation is removed, the space shall be back-filled with stone, gravel, or slag that will pass a four (4) inch sieve. The contractor shall make provision for any special drainage of the subgrade which may be ordered by the engineer, payment for which shall be made in accordance with the requirements for Payment for Extra Work Performed by Force Account. If the surfacing is to be of portland cement concrete, brick, or bituminous concrete, care shall be taken that the entire area of the subgrade in the rock cut is in such condition that the fresh concrete will not become separated because of interstices in the subgrade. Such interstices shall be filled with gravel, graded stone chips, and screenings, or otherwise, as the engineer may direct. The completed subgrade upon which the surfacing is to be placed shall conform to the cross section shown on the plans, with a permissible variation of not to exceed one-half (½) inch. Outside of the limits of the surfacing, the surface of the roadbed shall conform, with a permissible variation of two (2) inches, to the requirements of the plans. It shall be free from all projecting points and fissures or crevices greater than two (2) inches in width. If impracticable to excavation the rock to conform to this requirement, the excavation shall be carried below the established grade and the space backfilled with loose rock or gravel that will pass a four (4) inch sieve.

Method of Measurement.—All roadway excavation shall be measured in its original position and the volume computed by the method of average end areas.

In rock excavation vertical measurements for determining end areas shall extend from the surface of the rock to an elevation six (6) inches below the established grade (or subgrade, if there is one) as shown on the plans, or to the bottom of the rock where it does not extend to the established grade or subgrade; horizontal measurements for determining end areas shall extend six (6) inches beyond the slope lines fixed by the engineer for the work and to which the excavation is made. Payment will not be made for excavation beyond these boundaries, nor shall deductions be made for the portions which may not be removed between these boundaries and the true section shown on the plans.

Measurements shall not include any excavated material used for purposes other than for those designated, and shall not include any material excavated beyond the

limits of the required slopes, except as provided under Section 14, Borrow.

Basis of Payment.—This work will be paid for at the contract unit price per cubic yard for the class of excavation involved, which price shall be payment in full for all work specified under "Roadway and Drainage Excavation," and also for all items of work specified under the general heading of "Earthwork" for which no separate unit prices are included in the contract. Such payment shall include full compensation for all equipment, tools, labor and incidentals necessary to complete the work.

Embankment

Specifications, Illinois Division of Highways

Construction Methods.—All embankments shall be formed of good sound earth, stone, gravel, or other acceptable materials, and shall be built to sufficient height and width that after full shrinkage, they will conform to the cross section shown on the plans.

In the construction of all embankments, the material shall be deposited in uniform layers not more than nine (9) inches in thickness for the entire length and width of the embankment. Each layer shall be thoroughly disked, or treated by some other approved mechanical means which will insure the breaking up of all lumps, clods, etc., and the proper compaction of the embankment. The disc-harrow shall either be of a suitable heavy type or shall be weighted by some suitable means. When the soil is of such nature that satisfactory results cannot be obtained with a disc-harrow, the use of a tooth-harrow may be permitted at the discretion of the engineer. All embankments having a depth of three (3) feet or less and all embankments constructed of sand, gravel or rock may be paved without additional settlement by watersoaking. Except on proposed road improvements which are to be surfaced entirely with traffic-bound gravel or crushed stone, all embankments having depths greater than three (3) feet shall be settled by water-soaking immediately after completion. All water-soaking shall be performed in accordance with the provisions for Settlement of Embankments.

All culverts and bridges preferably shall be completed in advance of grading operations. If not so completed, an omission of not less than one hundred (100) feet on each side of such structures shall be made and the embankment adjacent thereto placed later in accordance with the requirements herein specified for the construction of embankments, or, an omission of sufficient length to permit the completion of the structure and the necessary backfill may be made, provided all backfills are constructed with gravel at the entire expense of the contractor.

When new embankments are to be constructed on existing embankments or hillsides, the existing slopes shall be plowed deeply, or deep steps cut therein before the filling is done, in order that the old and new materials may bond together. All portions of existing roadbeds within the limits of new roadbeds which are within a vertical distance of one (1) foot of the surface of the completed subgrade shall be thoroughly broken to a depth of not less than six (6) inches.

When embankments are constructed of stone and earth, the stone shall be well distributed and the interstices completely filled with earth. No stone four (4) inches or more in diameter will be permitted within twelve (12) inches of the subgrade.

No frozen material shall be placed in embankments. Objectionable quantities of snow and ice shall be removed from the surface which will be covered by the embankment, prior to constructing it.

The width and grade of all approaches to intersecting roads shall be as shown on the plans. The width of roadway for field and private entrances shall be sixteen (16) feet, the grade not to exceed ten (10) per cent, and the side slopes 1½ :1.

The use of drag line excavators or similar excavating equipment which deposits material in large unit masses will not be permitted unless all of the materials cast up by such equipment are moved from the point where they are deposited and placed in the embankment in uniform layers as specified herein.

Basis of Payment.—Embankment will not be measured or paid for directly but shall be considered as subsidiary work pertaining to the several classes of "Excavation" or to "Borrow."

Settlement of Embankments

Specifications, Illinois Division of Highways

Description.—This work shall be done when required by the plans or special provisions and shall consist of the introduction of water into embankments to accelerate settlement and work incident thereto. The equipment and methods used shall meet with the approval of the engineer.

Construction Methods.—The work shall be started as soon as possible after the embankment has been constructed and at the point of lowest elevation of the fill surface. The water shall be introduced through holes jetted into the embankment to a point approximately two (2) feet above the original ground line. The holes shall be arranged in transverse and longitudinal rows not more than six (6) feet apart. Each transverse row shall contain not less than four (4) equally spaced holes, with the outside holes not less than five (5) feet from the shoulder line. Additional holes shall be jetted to secure adequate settlement, if deemed necessary by the engineer. Rock, gravel, or other material encountered in sinking the holes shall be picked loose with crowbars or iron rods.

The water pressure used shall not be greater than that required to sink the holes at a moderate rate of speed and shall never be great enough to cut cavities through the slopes or bottom of the embankment. After the holes have been jetted, the water shall not be introduced at a rate greater than the capacity of the fill for taking it without excessive overflow or loss through the bottom or side slopes. At no time shall more than one water jet be operating in the same longitudinal row. Excess water on the surface shall be drained into the jetted holes by means of shallow trenches, and shall not be allowed to run over the side slopes of the embankment. A close watch shall be kept for water movements through the side slopes and bottom of the fill, and the introduction of the water shall be stopped upon the appearance of the water at these points. Whenever the work is stopped for this reason, a period for substance shall be allowed, after which the operations shall be continued. The introduction of water shall continue as long as the embankment will take an appreciable amount of water without losses through the bottom or side slopes and until the soil shows a satisfactory moisture content when test holes are bored between the water holes.

Behind bridge abutments no work shall be undertaken within a distance equal to one and one-half times the height of the abutment. Special care shall be exercised

on side hill embankment; short, deep embankments; and on embankments over cattle passes, culverts or old stream beds. All holes shall be filled with mud as soon as the work has been completed.

If the surface of the embankment is heavily crushed, it shall be scarified or deeply plowed and thoroughly water-soaked as soon as the final operations have been completed. No pavement shall be placed on embankments settled in this manner within ten (10) days after completion of the work, unless permitted by the engineer. This time may be extended if deemed necessary.

Method of Measurement.—This work shall be measured for payment on the basis of the number of cubic yards of fill in embankments above the original ground line as shown on the cross sections and shall be computed between points five (5) feet beyond the end transverse rows or jetted holes.

Basis of Payment.—If the contract contains a separate item for "Settlement of Embankments," the contract unit price per cubic yard of embankment settled, measured as specified, shall be payment in full for this work, including all equipment, materials, water, labor, and incidental work necessary for the completion of the work specified herein. If no such unit price is stipulated, the contract unit price for the several classes of "Excavation" or for "Borrow" shall be considered as including payment for this item.

Clearing

Specifications, South Dakota State Highway Commission

Description.—Clearing shall consist of the trimming of trees and the satisfactory disposal of all dead timber, brush, weeds, grass, fences, rubbish and stone, less than one cubic foot, within the limits of the right of way and all live timber, posts and signs from the area required for the roadways, slops, ditches, channel changes, borrow pits and structures.

Construction Methods.—Where an embankment of two and one-half (2½) feet or less in depth is to be made, all trees, stumps and root shall be cut off flush with the existing ground surface. Where an excavation or an embankment of more than two and one-half (2½) feet in depth is to be made, all trees, stumps and roots shall be cut off within six (6) inches of the original ground surface. All brush, weeds, heavy grass, and dead timber, shall be cut off flush with the original ground surface. The limbs shall be removed from timber of any value which it may be necessary to cut and such timber shall be piled neatly so as not to interfere with subsequent work. All tree branches which hang within twelve (12) feet of the roadway surface shall be carefully removed.

Timber of no value, limbs, stumps, roots, brush, weeds, grass, or other vegetable matter or rubbish shall be burned in such manner as not to damage surrounding trees or property. Stones or other non-inflammable materials shall be piled in neat piles along the right-of-way so as not to interfere with subsequent work. In no case will it be permissible to merely throw stones or refuse outside of the right-of-way or place same in windrows at the side of the right-of-way.

Fences necessary to be permanently moved back on right-of-way lines will be moved by the county or state. All other fences, posts, signs, or letter boxes necessary to be moved shall be moved by the contractor and disposed of by him as directed.

Trees which will neither interfere with construction operations nor damage the road must be carefully preserved.

Method of Measurement.—The quantities to be paid for shall be the number of trees cleared from six to eighteen inches in diameter, trees over eighteen inches in diameter and clearing not covered in the two classifications above mentioned.

Basis of Payment.—The price to be paid for clearing will be the contract prices for cutting and disposing of trees from six to eighteen inches in diameter, trees over eighteen inches in diameter, in addition to the lump sum bid for clearing not covered in the two classifications above mentioned. The diameters of the trees are to be measured above the ground swell.

Grubbing

Specifications, South Dakota State Highway Commission

Description.—Grubbing shall consists of the removal of all stumps, all heavy roots (to be understood to mean roots of six (6) inches or more in diameter), and all grubs remaining, after clearing operations are completed, within the areas required for the roadway, ditches, borrow pits and slopes except where the depth of an embankment at the point in question is more than two and one-half (2½) feet above the original ground surface. Grubbing shall not include the removal of grass or weed roots unless so stated in the "Special Provisions."

Construction Methods.—In the grubbing of areas to be excavated, all stumps, all heavy roots, and all grubs shall be removed to a depth of not less than nine (9) inches below the subgrade surface of the roadway, ditches and slopes, and all holes below subgrade surfaces made by grubbing operations shall be refilled with acceptable material which shall be compacted to make the surface at these points conform to the surrounding subgrade surface.

Stumps, roots and grubs shall be piled in convenient piles along the right-of-way and burned in such manner as to not damage surrounding trees or property. In no case shall stumps, roots and grubs be placed in embankments.

Grubbing operations shall precede grading operations.

Method of Measurement.—The quantities to be paid for shall be the number of stumps grubbed from six to eighteen inches in diameter and stumps over eighteen inches in diameter.

Basis of Payment.—The price to be paid for grubbing will be the contract prices for removing and disposing of stumps from six to eighteen inches in diameter and stumps over eighteen inches in diameter, the diameters of the stumps to be measured just above the ground swell.

Borrow

Specifications, South Dakota Highway Commission

Description.—Where the amount of the embankment exceeds the amount of the excavation from side ditches and excavations as staked out, the contractor shall make up the deficiency from borrow pits to be first staked out and cross-sectioned by the engineer. Unless otherwise provided, the location of borrow pits will be shown on the plans. Borrow pits will be furnished to the contractor.

Construction Methods.—In no case is a borrow pit to be located closer than five (5) feet to the toe of the fin-

ished slope of an embankment. Borrowing must be done from regular shaped borrow pits, in order to admit of ready and accurate measurements, care being exercised not to unnecessarily injure or disfigure lands adjoining the borrow pits or over which borrowed material is hauled. The slopes and bottom of borrow pits shall be so constructed that water will drain out of the same and the borrow pits and adjacent lands left in a neat and sightly condition.

Method of Measurement.—Borrow shall be measured in its original position and the volume of the material moved shall be computed by the method of average end areas.

Basis of Payment.—The yardage of borrow measured, as provided above, shall be paid for at the contract unit price bid per cubic yard for excavation, according to the classification of material excavated, which price shall be payment in full for all work specified in this section.

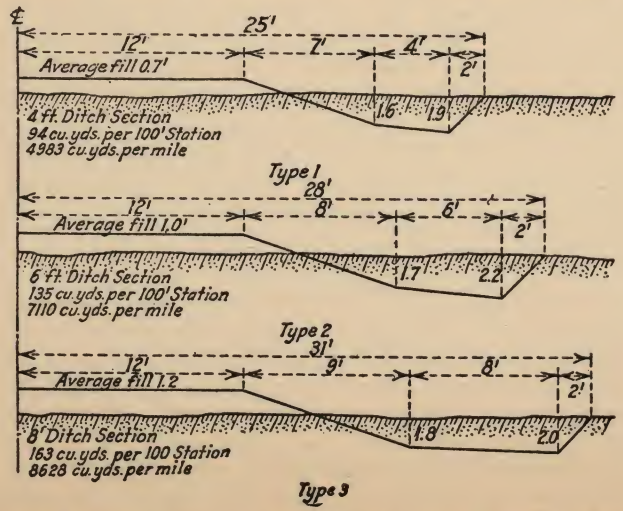
Blade and Cast in Work

Specifications, South Dakota State Highway Commission

Description.—Blade and cast in work shall consist of forming side ditches and shoving the material therefrom and properly placing it in embankments by means of a blade grader or otherwise and forming the entire roadway in strict accordance with the alignment, cross-section and profile grade shown on the approved plans. No hauling is included in this work.

Blade and cast in work may be specified where the ground line and grade line, as shown on profile, are parallel or symmetrical and it is practicable to form side ditches, which will drain, and place the material excavated therefrom in embankment by means of a blade or elevated grader. Blade and cast in work will not ordinarily be specified where the continuous length of such work is less than 2,000 feet unless several distances of shorter length totaling 2,000 feet or more are separated by short distances requiring hauled material. The work in such intermediate sections (and all earth work) involving hauling shall be paid for in accordance with Articles 12.1 to 12.5 inclusive.

Construction Methods.—The work shall be staked out as provided in Article 5.6 of the Specifications save that instead of at random distances from the center line the usual survey stakes shall be placed on the line of the proposed finished back slope cut. Grade stakes giving profile grade as shown on approved plans shall be set at points not further than 100 feet apart along all the work. All weeds and rank growth between these stakes shall be cut and burned. In marking out, a light cut shall be made running true to these stakes. The full width of the ditch section shall then be stripped of all sod, which shall be well pulverized and spread across the area under embankment or wasted as directed by the Engineer. The blade cuts shall then be stepped in and down from the first cut and following the general line of the required finished back slope, leaving the back slope to a finished plane. Ditches must be left free from pockets or high points that would cause standing water and the blading must be continued until the required section is formed and the roadway surface is compacted, smooth and free from all clods, sod or stone. A disc harrow shall be used when ordered by the Engineer to pulverize clods or sod.



Standard Blade Grade Sections, South Dakota State Highway Commission

(a) Widening and Shaping of the Road. Where the road under construction has previously been graded and the ditches are not cut the required distance from the center, the following method will be used: After all weeds have been removed, the sod shall be stripped from the area between the stakes and deposited in the bottom of the old ditches. Where it is evident that the old ditch is not deep enough to permit depositing the sod and covering same with earth, the sod shall be plowed and disc harrowed until the same is thoroughly pulverized. The roadway shall then be finished in conformity with the alignment, grade and cross-section shown on the plans.

(b) Side Hill Work. Blade and cast in work may be designated where the transverse slope is not greater than twelve to one. The first, or marking out cut, will be made to stakes set out to conform to the approved section for side hill construction and to the profile grade shown on the plans. All sod will be stripped for the full width of the excavation and bladed to the outer edge of the embankment, a light cut may be made marking out the toe of the slope of the embankment but no other cutting will be allowed on the low side.

Method of Measurement.—Blade and cast in work shall be measured by the lineal foot along the centerline of the roadway.

Basis of Payment.—Blade and cast in work will be paid for by the lineal foot at the price bid, which payment shall be in full for all work and the furnishing of all tools, equipment, labor and materials necessary. No work shall be paid for which is not finished in accordance with the alignment, profile, grade and cross-section shown on the approved plans.

New Edition of Bulletin on Mineral Identification

A new edition of United States Geological Survey Bulletin 679, "The microscopic determination of the nonopaque minerals," has just been published as Bulletin 848 and may be obtained from the Superintendent of Documents, Washington, D. C., for 20 ct. The previous edition appeared in 1921.

The new edition of 254 pages has been completely rewritten and the tables brought up to date by the introduction of about 500 new entries and 100 changes in old entries. About 250 new mineral species not given in the old edition are included, and tables have been added in which the data on the important mineral groups have been assembled. The new edition will therefore entirely supersede the earlier one and will be a necessary reference work for all those who have occasion to identify minerals.

Grading With Blade Grader—Methods and Costs

Messrs. Victor J. Brown and Carleton N. Connor, in their treatise, "Low Cost Roads and Bridges," published in 1933, give the following:

Many of our roads are built and maintained by blade grading methods. The following discussion pertains to a roadway of sufficient width for travel on some of our county roads as well as township roads.

Successive Rounds of Grader.—The diagrams illustrate the method of grading an earth road. Typical for many old roads is a level stretch of roadway with light ditches and balanced section, in which the roadway is approximately level with the adjacent land.

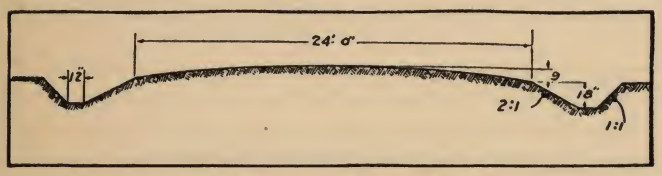


Fig. 1.—Cross Section of Roadway

Level Section.—For the first cut on a road, the blade is set to cut an even depth along its entire length and at a sharp cutting angle nearly parallel to the direction of travel.

When the grading has been completed, the surface of the road should be free from sods. This requires that the sods be reduced to a minimum and that the quantity of fine earth be a maximum. As most of the sods come from the first cut of the grader, this cut should be as shallow as possible without permitting the blade to come out of the ground; under ordinary conditions this will mean a cut two or three inches deep. The resulting sods will be thin and pliable; in addition, the total volume of sods will be small, and they can be cut up easily and covered.

In making the first cut, the point of the blade should be kept a few inches inside the outer edge of the finished ditch. Then, by having each of the successive ditch cuts a little deeper and a little nearer the center of the road, the rough ditch will have a stepped-back face as shown in cross-section by the dotted lines of Figure 2. With the point of the blade located as described, and with the stake-line at the middle of the ditch, the operator will be in a position to sight along the stake-line when he makes the first cut.

It is very important that the first cut be straight, as the succeeding cuts are governed by the first, and any curve which appears in the first cut is likely to persist in the finished ditch.

On the second round of the grader, the ridge of sods formed by the first round, is broken up and spread so that it can be covered with fine earth obtained in later cuts from the ditch.

For the second ditch-cut, which is the third round of the grader, the point of the blade is set a little deeper than the heel in order that the ditch may be deepened without disturbing the earth which forms the shoulder. The dotted lines in Figure 2 represent a section of the second ditch-cut. It is to be noted that the second cut does not extend as far to the right as the first, and that the stepped face of he rough back slope becomes apparent. The grader should be hitched to the tractor with just enough offset to insure that, with the grader making a ditch-cut, the outside wheel (or track, in the case of a crawler tractor) of the tractor will run on this spoil.

There are three distinct advantages in having the tractor run on the shoulder when the grader is in the ditch. First, the tractor is clear of mud and water, and it can, therefore, deliver a maximum drawbar pull. Second, the sods during the first ditch-cut are cut to pieces and rolled down during the second cut so that the grader, in transferring earth from the shoulder to the center of the road, does not move the sods. Thus, the sods are not only kept off the center of the road, but by the time the road is finished, they have been for the most part entirely cut to pieces. Third, since successive passages of the tractor pack the shoulder, by the time the road is finished, the shoulder is solid and more stable than a shoulder of loose earth would be.

The fourth round of the grader is to move the excess earth from the shoulder toward the center of the road. For this work the blade should be set a little straighter across the road than for the ditch-cuts. This is done in order that the earth may be transferred a maximum distance with a single passage of the grader.

The blade should also be placed low enough to transfer the loose earth resulting from the second ditch-cut, but high enough to slip over and not disturb the sods of the first ditch-cut. If this is done, and it can be done with a high degree of success by a competent operator, the loose earth will be in the center of the road, and the sods will remain at the shoulder where they are further ground up and packed down by successive passages of the tractor.

Transferring the earth from the shoulder toward the center of the road necessitates a much smaller draw-bar pull than the ditch-cut does, so that, if a tractor having three speeds is used, it can be run in "intermediate" or even possibly in "high" for this round, thus expediting the work.

The fifth round of the grader was the third ditch-cut, the earth removed from the ditch being represented in cross-section by the dotted lines of Figure 2. For this cut, the blade is again set nearly parallel to the edge of the road; the point of the blade is set down, while the heel is kept up so as to clear the solid ground at the shoulder and to deliver the spoil just inside the shoulder line; the point is kept away from the back face in order to cut another step in the rough back slope. This passage of the grader leaves a ridge of mellow earth on top of the sods just inside the shoulder line.

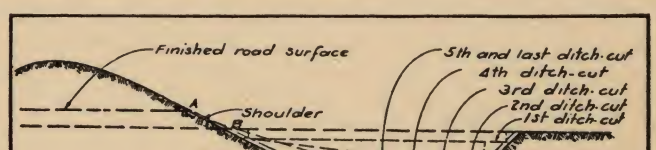


Fig. 2.—Cross Section Showing Cuts Taken by Successive Passages of Grader. As the point of the blade is lowered for the successive rounds, the heel is raised so as not to disturb the shoulder, AB. For successive cuts the blade is kept away from the finished back slope

In the sixth round of the grader, the loose earth is transferred from the shoulder toward the center of the road. As in the third round, the blade can be set a little more across the road than for the ditch-cut; and the tractor, if it has three speeds, can be run in "intermediate" or "high."

This operation is essentially the same as that of he fourth round, with a difference, however, in the case of an unbalanced road section. It is at this point that the correction of an unbalanced section is begun.

On the seventh round the back-sloper is attached and the fourth ditch-cut made. The back face of the ditch is cut on a slope and the ditch deepened. This cut delivers a ridge of fine, loose earth on the line of the shoulder which is later used to finish the surface of the roadway.

The eighth and ninth rounds carry the loose earth from the shoulder toward the center and distribute it in such a way that at the end of the ninth round the road approximates the finished section.

The tenth round of the grader is the fifth and last ditch-cut. In this round the back slope of the ditch is smoothed up, and any loose material in the ditch is cleaned out and discharged on to the shoulder. In order to deliver this earth to the shoulder, the blade should be tipped forward at the top. This cut deposits on the shoulder a quantity of fine, loose earth, which is in excellent condition for distributing over the road to complete the finishing of the surface.

By cutting the back slope smooth and at an easy grade, the grader makes a ditch much less likely to fill than if the backslope is left rough or vertical. Besides, the smoothly cut back slope gives the road a finished appearance.

As a result of the eleventh and twelfth rounds, the loose earth is again transferred from the shoulder toward the center of the road, and the road is brought to a finished surface.

Old Road in Deep Cut.—An old narrow road between high banks is widened by pulling down the banks, raising the level of the roadway with the earth so moved, and forming side ditches for the drainage of the roadway.

The first two or three rounds with the grader results in cutting down the banks and moving the earth out to form a level portion along the banks on which to operate the machinery in a level position. It is also possible to successfully cut down a high bank by beginning at the bottom of the slope. The adjustment of the leaning wheels on the grader makes it possible to start on the side of a very steep bank and begin the cutting at the top.

Balancing Cross-section.—Another condition often encountered in old roads is to have one side higher than the other. This is often the case on ground sloping transversely to the roadway with a high bank on one side, the other side being lower than the roadway itself. In grading such a road, it becomes necessary to transfer earth completely from one side to the other.

The diagram shown in Figure 3 represents the cross-section of an unbalanced roadway. The heavy, full lines show the condition of the natural road; the dotted lines show the position of earth after the fifth round of the grader. The spoil from the ditch-cuts on the low side is discharged on the line of the shoulder and allowed to remain in that position. The spoil from the ditch on the high side is moved across to the center of the road by an extra round of the grader. On the return trip of this extra round, the blade of the grader is reversed so that all the loose earth on the high shoulder is moved towards the center of the road. In some cases two extra rounds on the high side of the road may be necessary to obtain the desired result. This can best be done after two or three ditch-cuts have been made, to provide sufficient loose earth for filling the low side of the road. The extra amount of earth obtained from the high side in back-sloping the bank as indicated in the drawing, can best be disposed of in such manner as described herewith. Extra heavy cuts are necessary on the high side, in order that the bottom of the ditch may be cut to a level with the ditch on the lower side.

Items Included in Cost of Road.—Records kept on operations give the cost of grading a road. This cost includes a consideration of the original investment in the machinery; interest, depreciation and repairs; the cost of material and supplies and the pay of men required to do the work. The tractor that can be used on this work retails in the U. S. at about $6,250 and the grader, including backsloper, at $1,790. The life of the machinery cannot be exactly determined, but a reasonable estimate for the equipment used would be to assume that it would last five years, working one hundred twenty days per year, at this kind of work and under average conditions.

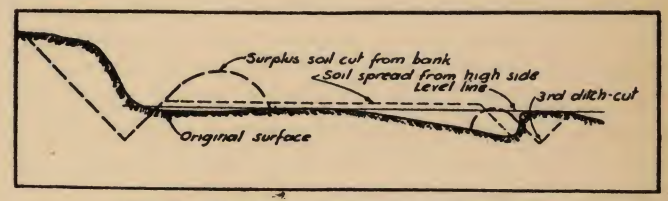


Fig. 3.—Method of Balancing Road Section

The fixed charges on this work have consequently been estimated as follows: these figures are given primarily to show the formula for figuring fixed charges.

Initial Cost of Machinery		Annual Cost of Machinery	
Tractor	$6,250.00	Depreciation at 20%	$1,608.00
Grader	1,790.00	Interest at 6%	482.40
		Repairs at 4% (Est.)	321.60
Total	$8,040.00	Total	$2,412.00

Daily cost of machinery, based on 120 days per year.....$20.10
Hourly cost of machinery, based on 9 hours per day..... 2.23

The grading crew will consist of two machinery operators, and the pay is based on the rate of regular mechanic's wages for such work; the tractor operator's wages are taken at $8.00 per day and the grader operator's wages at $6.00 based on a nine hour day. The actual time of operation of the machines is noted and all the items of cost computed on this basis. Due allowance should be made for lost time for repairs, and for rainy days, which of course is variable and cannot be estimated here. Following is a tabulation of data pertaining to all the items involved in the cost of grading a road.

Length of road graded.....2.12 mles
Amount of earth moved.....4,468 cu. yds.
Total time—actual operation.....36 hours

OPERATING COSTS

	Rate	Amt.	Total Cost	Per Mile	Per Day	Per Hr.
Tractor oper.	$8.00	36 hr.	$32.00	$15.09	$ 8.00	$0.89
Grader oper.	6.00	36 hr.	24.00	11.32	6.00	0.67
Gas	0.236	210 gal.	49.56	23.38	12.39	1.38
Eng. oil	1.00	16 gal.	16.00	7.55	4.00	0.44
Tractor oil	0.30	22 gal.	6.00	3.11	1.65	0.18
Grease	0.20	36 lb.	7.20	3.40	1.80	0.20
Mach. invest. cost	2.20	36 hr.	80.40	39.72	20.10	2.23
Overhead	...	.....	32.36	15.27	8.09	0.90
Total			$248.12	$117.04	$62.03	$6.89

Cost per cu. yd. = 5.55c.

The cost figures given above are the average for unfavorable weather on which some heavy grading is encountered. The conditions here are about what would be encountered in rolling country prevailing over the greater part of the central and northern sections of the states.

However, in level country, where light grading would be sufficient to put a road in good shape, the cost of grading may be somewhat lower. In order to determine the cost of grading under such conditions, a short section of level road might be graded as a separate unit and the cost determined.

The following data show the results to be obtained:

Length of section.....900 ft.
Amount of earth moved.....432 cu. yds.
Time required to complete section.....2¼ hrs.
Cost per hour.....$ 6.89
Total cost of grading section.....$15.50
Cost per mile of road.....$90.92
Cost per cubic yard of earth moved.....3.6c

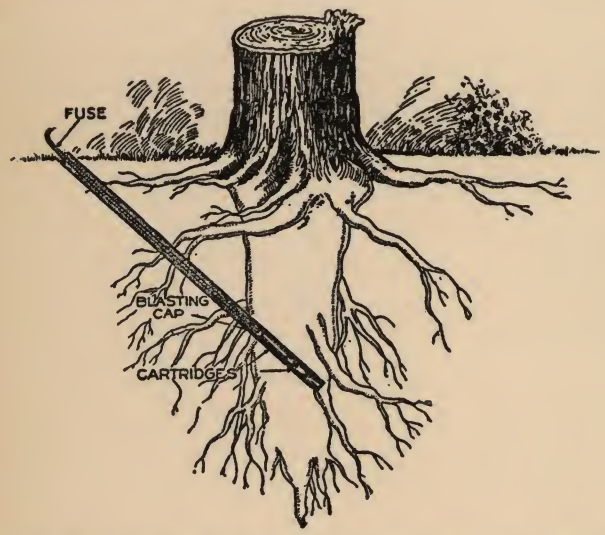
Explosives in Road Work

Explosives are used for many purposes in road work. These include removing stumps and boulders; loosening hard ground in grading; blasting rock in grading; blasting for surfacing material; opening ditches, and opening vertical drains. We are indebted to Hercules "Modern Road Building and Maintenance" for the matter in this section dealing with blasting stumps and boulders and to the du Pont Blasters' Hand Book for that dealing with blasting cuts.

Blasting Stumps.—There are two methods of placing the charge in blasting tap-rooted stumps.

When the brace roots are small, and it is desired to use a minimum of powder at the expense of a little more labor, the best way is to expose the tap root to a depth of 18 in. or 2 ft., or to make a hole with a soil auger or punch bar that will strike the root about 2 ft. below the surface. A hole is then bored with a wood auger somewhat more than half through the root. In loading, the cartridges should be split, and all of the charge packed into the hole in the wood if possible and the remainder of the hole then filled to the surface with moist clay or other available stemming material, and well tamped. Where much work is involved, a boring machine with a power-driven auger can be used advantageously.

Where the boring of the root or the stump involves too much time or expense the stump may be removed by simply placing at least 2 ft. below the surface of the ground, but snug up against and symmetrically around the tap root, two or more charges of dynamite which are then exploded by a blasting machine. Sometimes a single large charge is placed in this manner. This method requires more powder, but less labor, than that described in the preceding paragraph.



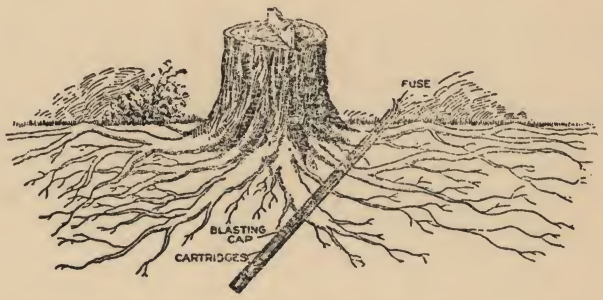
Charge Properly Placed for Blasting Stumps Having Tap Roots.

If it is desired to place a heavy charge in a hole or to concentrate the load in the bottom of the hole, an enlargement of the bottom for this purpose may be effected by "springing." To spring a hole a light charge of one-quarter or one-half a cartridge is exploded in the bottom.

When shooting a single hole, fuse and blasting cap are entirely satisfactory, but when there are more than one, a blasting machine should be used, so that all the holes will explode simultaneously, each, in this way, assisting the other.

The proper loading will best be determined by practical tests on the ground. The blasting of half a dozen stumps will give a very good line on the most economical amounts of explosive to use under the existing conditions.

When blasting stumps having heavy spreading lateral roots, a charge placed under the center of the stump alone might result in merely splitting the stump, the large roots remaining and holding the split pieces. This method is successful with small, lateral-rooted stumps, but in the case of large stumps charges must be placed also under each of the heavier roots, the amounts depending upon the size of the roots, which can be determined with a ¼-in. pointed steel rod or searcher. A blasting machine should be used for simultaneous firing.



Charge Properly Placed for Blasting Stump Having Lateral Roots.

When using a single charge under a small stump of this kind or under an old stump with decayed center, the load should be placed a considerable depth below the butt, so that a substantial cushion of earth will distribute the force of the explosive and prevent mere splitting of the stump.

In the Pacific Coast States, redwood, fir, pine, and cedar trees grow to enormous size. Their roots usually stay near the surface, due, in a large measure, to the wet climate. These stumps can be removed in the same manner as the smaller stumps of similar type. As an indication of the amount of explosives required to remove these stumps, square the largest diameter in feet. The result will give the approximate number of 1¼x8-in. sticks necessary. This is no fixed rule, but merely indicates a point from which to start.

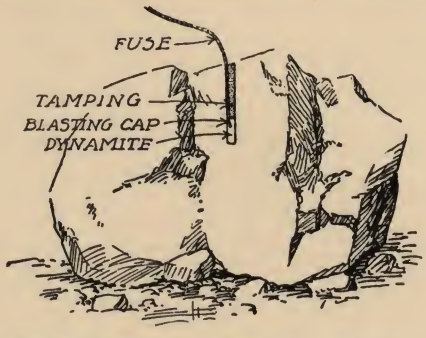
For blasting stumps in dense, heavy soils, such as those containing muck, clay or silt, a low strength explosive is most satisfactory. Twenty to thirty per cent strength is best for this work. In coarse, light, dry soils, such as sand, higher strength powders, 50 to 60 per cent are required for good results.

Blasting Boulders.—There are three methods of blasting boulders: mudcapping, blockholing and snakeholing, or undermining. Mudcapping is most commonly used because it requires neither drilling nor punching of holes and causes the least scattering of pieces. The explosive is merely laid upon the rock at a point where the most effective blow might be struck with a heavy sledge hammer. The charge should be well covered with moist clay or earth, firmly packed down. Mudcapping requires practically no labor, but more powder is necessary than with either of the other two methods. It is best adapted to use on rather flat-shaped boulders having a brittle structure or well-defined lines of weakness.

With the blockholing method, a hole is drilled into the boulder, the explosive placed in the bottom of this hole and tamped firmly, and the charge fired in the usual way. Blockholing requires the most labor of the three methods,

but uses the least powder. With the hole properly placed, and of the right depth, a surprisingly small quantity of explosives will accomplish the desired work. The depth of the hole depends upon the character of the rock, a deep hole being required in brittle or tough rock, while a shallow hole can be used in crumbly or easy-splitting rocks.

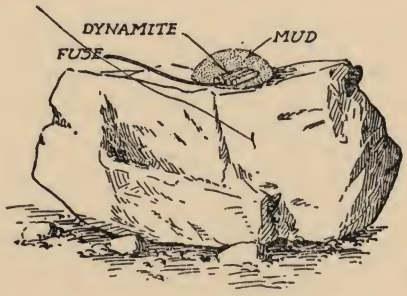
If the boulder is partly embedded, and in such a position that neither mudcapping nor blockholing can be used advantageously, the snakeholing method is employed. A



Blockhole Method of Blasting Boulder.

hole, or holes, is dug or punched with a bar beneath the stone, and the charge of explosives placed against its underside, and well tamped. This method requires less dynamite than mudcapping because of the better confinement. The size of the embedded rock and the quantity of explosives to use are determined with more accuracy, and the blast throws the pieces of rock out of the hole, so that handling is facilitated. A light, well-placed charge may be made to roll the rock out of its bed, one of the other methods then being used to break up the boulder.

The quantity and grade of explosives to use in boulder blasting depends upon the character and size of the boulder and the method employed for breaking it. When mudcapping, a fast, high-strength explosive should be employed, such as 50 or 60 per cent extra ammonia dynamite or straight nitroglycerin dynamite, the latter being better for very hard, tough rocks. Because of the confinement of the charge in snakeholing and blockholing, the quick, smashing blow is not required, and 25 to 40 per cent powders are better for these methods.



Mudcapping Method of Blasting Boulder.

Blasting "Through" Cuts.—Hard ground whether clay or rock is loosened in through cuts by blasts loaded in either flat or vertical holes. The selection of the direction of the holes will depend on the nature of the ground. For ground having flat or horizontal seams the vertical hole is usually preferred; while flat holes are usually best when the seams are vertical or the ground hardest at the top.

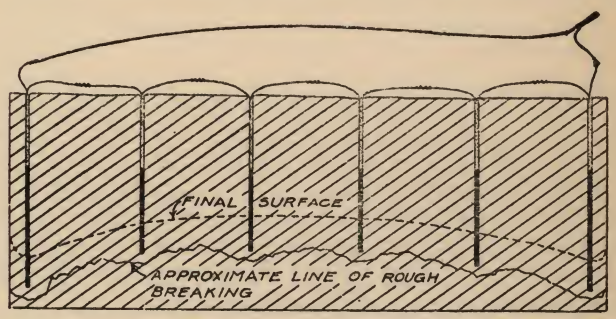
When vertical holes are used the best practice is to drill a line of holes all the way across the cut. These should be drilled somewhat below the grade, usually about 1 ft., to insure that no high spots are left between and in front of the bore holes.

These holes usually can be spaced apart in distance from three-quarters to four-fifths of their depths for holes less than 6 ft. deep. Deeper holes are usually spaced from one-half to three-fourths of their depth apart.

The burden or distance back from the face must be governed by the resistance of the ground to breaking. This distance usually can be slightly greater than the spacing between the holes.

For this blasting electric firing is to be recommended most strongly, as a given amount of explosives in such a load will do more work when all holes are fired together than when fired singly.

The spacing between holes is about the same for flat as for vertical holes, but as a rule, flat holes can be

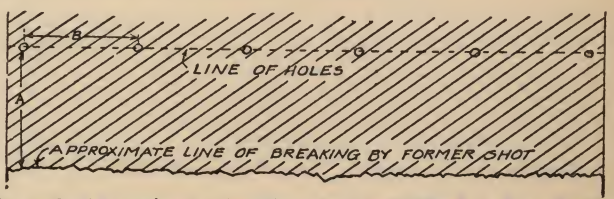


Elevation of Approximate Loading for Cut Work. To Give the Proper Crown and Sufficient Depth for the Side Ditches the Holes Away from the Center Are Drilled Deeper.

drilled deeper, or in other words a heavier burden can be handled.

The quantity of explosives to use for earth work will depend upon the hardness and character of the ground, the burden on the holes, and the explosive that is used. As a point from which to start, a pound of dynamite for 3 or 4 cu. yds. of material may be used in test shots, and the quantity then varied to meet conditions. A comparatively low-strength explosive should be selected.

The quantity and kind of explosives to use for rock work will be governed by several considerations. The nature of the rock, its relative hardness and toughness and the method of blasting and spacing holes must all be considered. A few test shots will do much to establish the most economical and effective practice. Rock work requires relatively high strength explosive; 30 to 60 per cent dynamite is commonly employed.



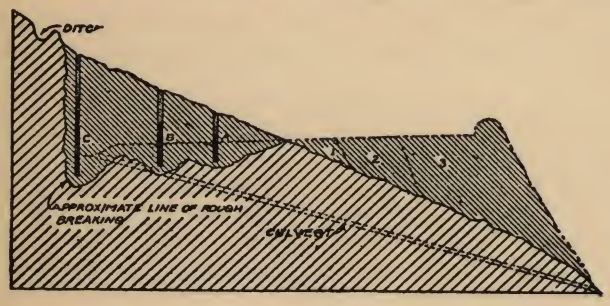
Plan of Approximate Loading for Cut Work. For Shallow Cut the Burden "A" Is Usually Slightly Greater Than the Depth of the Cut and the Spacing "B" Is Slightly Less. For Deeper Cuts, Especially in Rock, Spacing Is Usually One-half to Three-quarters of Depth and the Burden About Equal to the Spacing.

Side Hill Cuts.—There are two methods of making these cuts. In one method all of the ground is excavated and the road bed is on solid ground. In the other the cut is not made so wide, but the spoil is used in filling up the lower side to get the desired width.

In either case the cut can be worked from the side or the end. Working the full width of the cut from the

end is better, especially if the spoil or muck is to be used elsewhere for a fill. This keeps a better cart way open. In working from the end, the general rules laid down for through cuts apply, and the same explosives and loading are recommended.

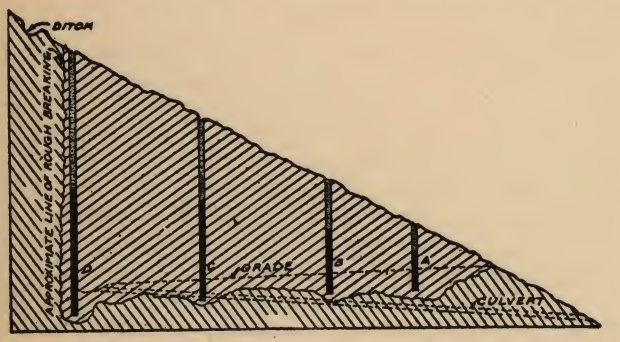
In working from the side, slight variations are made depending on whether the excavated ground is used again



Approximate Method of Loading for Side Hill Cut and Fill. In Earth or Clay the Side of the Cut Should Be Sloping to Prevent Caving. Another Short-Hole in the Top of the Bank Will Aid in Making This Slope.

for filling or wasted down the hill. If it is to be used for filling, the loading should be barely heavy enough to break the ground in good condition for handling. When it is to be wasted down the hill, heavy loading will throw it away so that little rehandling is required.

High Sides.—In highways the removal of high sides, ridges and "thank you marms" of compacted clay or of

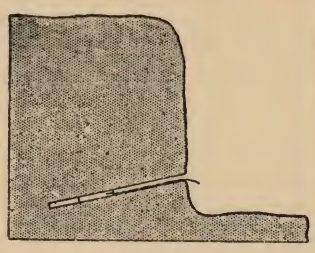


Approximate Method of Loading for Side Hill Cut Where Excavated Material Is to Be Wasted or Hauled Elsewhere. In Earth the Side of the Cut Should Be Left Sloping Instead of Vertical, to Prevent Caving.

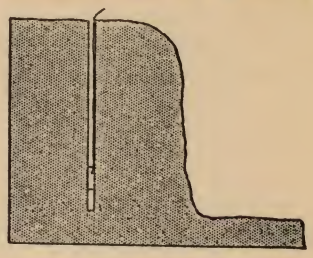
rock is accomplished by drilling shallow holes and loading them with 20 per cent ammonia dynamite. Such blasts so loosen the ground or rock that it can be moved by means of scrapers and little or no hand labor is required.

Miscellaneous Operations in Road Building.—Digging outfall or discharge ditches is accomplished by blasting in exactly the same manner as for general ditching. Side ditches are blasted in the same way. Light blasts are used to loosen the ground for road machines or hand digging. The blasting of trees, stumps and boulders from both side and outfall ditches is most effective. For the general drainage of the right of way much good can be done by blasting for stream correction. Vertical drainage is frequently effective for draining land-locked basins through which roads must pass. For widening and straightening cuts the loading and explosives used are the same as for side hill cuts. Blasting down gravel and other road surfacing reduces the amount of labor required for loading. Blasting for speeding up steam shovel excavation is effective. The bore holes are spaced about as for other blasting but, unless rock is encountered, are loaded much lighter, the object being simply to blast enough to loosen the material, making the digging easy.

Blasting Ledges.—The quantity of explosives required for blasting in drilled holes in ledges can be gauged by



Location of a Flat or Horizontal Bore Hole in Road Cut.



Location of Deep Vertical Bore Hole in Road Cut.

the table printed above showing the amount to use per cubic yard of rock. Half again as much explosive should be used in a ledge blast as in a boulder. Measure the distance from the open side or face of the ledge back to the drill holes, and compute the number of cubic yards that should be broken off.

APPROXIMATE NUMBER OF POUNDS OF EXPLOSIVE REQUIRED PER CUBIC YARD ROCK

	Mudcapping Lb.	Snakeholing Lb.	Blockholing Lb.
Sandstone, slate and similar soft or easily broken rock	1	¾	¼
Limestone and other intermediate rock	1¼	1	⅜
Marble, trap, granite and similar hard tough rock	2	1½	½

APPROXIMATE QUANTITY OF EXPLOSIVE REQUIRED TO ROLL OUT BURIED BOULDERS

Diameter Boulder	Cartridge	Diameter Boulder	Cartridge
1½ ft.	½	4 ft.	1½
2½ ft.	¾	5 ft.	2
3 ft.	1		

APPROXIMATE NUMBER OF 1¼×8-IN. CARTRIDGES REQUIRED FOR BLASTING BOULDERS OF VARIOUS SIZE.

Greatest Diameter of Boulder, Ft.	Sandstone slate and similar soft, more easily broken rock	Limestone and other intermediate rock	Marble, granite, trap and hard, tough rock
	Mudcapping		
1½	1¼	1½	2½
2	1½	2	3
2½	1¾	2½	3½
3	2	2½–3	4
4	4–5	5–7	
5	7–10		
	Snakeholing		
1½	1	1¼	2
2	1¼	1½	2½
2½	1½	1¼	3
3	1¼	2	3½
4	3–4	4–6	
5	6–7		
	Blockholing		
1½	¼	¼–⅜	½
2	⅜	½	¼
2½	½	½	1
3	½	¼	1
4	1	1¼	2
5	1½	2	3
7	6	8	10

Tests of Rubber Paving in Milan, Italy

The engineers of the Commune of Milan, Italy, are now making tests of rubber as a paving material. The experiment with composition rubber tiles or blocks is being carried on in Milan on a section of street about 100 ft. in length, in a busy part of the city where traffic, both vehicular and pedestrian, is heavy. Similar experiments are reported to be under way in the city of Turin.

The Milan experiment is being made with thin rectangular tiles of rubber composition, about 11 by 8 in. in size, and 8/10ths of an inch thick, with dovetailed edges, laid in a thin asphalt cushion on an ordinary stone and concrete foundation 8 in. deep.

Settling Fills with Explosives

By L. F. Livingston, E. I. du Pont de Nemours & Co.

Explosives have been used to speed up the settlement of highway fills for several years with an ever increasing success. It is very essential first that complete soundings be taken of the swamp to be crossed. Too many engineers at the present time are guessing at what they have beneath the surface of the swamp and to what depth the unstable material goes. It has been found that it is an economy to take a set of three soundings across the proposed fill every 50 feet. These should be taken with a type of equipment that will give definite information of the different strata of underlying material as well as their depths and extent.

There are three variables which must be taken into consideration on every settlement job: 1st, the type of unstable material; 2nd, the water content of that unstable material; 3rd, the type of fill material that is going on top of the marsh. Each of the above has a direct bearing on how the job is done. If the marsh is soft, the fill will of its own weight settle further into the marsh and require the final displacement of less material. If the unstable material is of a stiff consistency, but has a large percentage of moisture, it can be readily liquefied with dynamite making natural settlement much greater. If the material going into the fill is a sand or free flowing gravel, it will readily drop into any holes or pockets that explosions make, while if the fill is of a clay consistency, it quickly sets up a bridging effect within the fill which makes a very different type of shooting necessary.

The blasting of highway fills at the present time throughout the country comes under three headings, but it must be remembered that every swamp is somewhat different from every other one and therefore trial shots should be made and the results examined before a final loading diagram is set up for the entire job.

Trench Shooting Method.—The first (see Fig. 1) is sometimes known as "Trench Shooting." The idea is to shoot a large ditch along the centerline of the right of way, to throw out the greater portion of the soft material and to so liquefy the balance of the material that when the fill is put in it will push out that balance and give a solid embankment to hard bottom. This method is used with success up to 10 feet in depth.

In the trench method of shooting, a 60 per cent straight nitroglycerine ditching dynamite is used, because when the holes are properly placed only one cap is needed to set off any quantity of holes. When the first hole is exploded by a cap, each of the others is exploded by the shock from the first hole. This is known as propagation shooting and when the ditching type of dynamite is used, there is an economy not only in the number of caps used, but also in the time required to load and wire the shot. Any one of the three general methods of blasting ditches may be used for trench shooting. These three are called the cross-section method of loading, the relief method of loading, and the post hole method of loading.

In the cross-section method, rows of holes are put cross-wise of the roadway.

In the relief method, two ditches are shot on either side and then the center material is removed by a final blast.

In the post hole method, a single row of holes with large charges are made along the centerline, usually from 5 ft. to 6 ft. apart.

The quantity of dynamite required in each hole depends entirely upon the method employed. Generally speaking, it requires 1 lb. per cubic yard to blast an open ditch, depending upon the type of soil, the moisture content and the amount of stumps to be blasted out at the same time. However, in this type of work the area surrounding the ditch is so liquefied that the fill material readily displaces a yardage much greater than the open ditch. Considering all these factors—type of soil, moisture content, stumps and the yardage of fill material settled into place, the amount of dynamite per cubic yard of fill has varied from as low as ⅓ lb. per cubic yard up to as high as 1½ lb. per cubic yard. Experience shows that ½ lb. of dynamite per cubic yard of final displacement is a safe figure to use.

In all types of trench shooting, the material is thrown for a considerable distance on either side of the roadway. This limits the use of this method to locations where there are no adjacent buildings.

Underfill Method.—The second method is what is often called "Underfill" shooting (see sketch). The idea here is to tear up the surface mat then place the fill and load the dynamite under the fill in such a way that a cavity will be opened up in the soft material and thus allow the fill to drop through to hard bottom. This method with its adaptations is used most at the present time and is correct for swamps from 10 ft. to 30 ft.

It is essential that all of the required depth of fill be placed over the marsh before any underfill shooting is done. The dynamite placed under the fill should be limited to such a quantity that the fill material itself will not be raised over 10 ft. to 12 ft. by the blast. When the load is greater than this, some of the fill material is usually shot away and wasted. A rule of thumb is to use in a single hole 3 to 4 lb. per foot depth of fill material above the load. This should be followed regardless of the depth of muck or unstable material to be handled. This is the reason for placing all of the required fill material in place before any shooting.

Soundings should be taken to insure the correct depth of fill. The type of material in the fill has a direct bearing on the placing of the shots under the fill. In sand or a free flowing gravel, the general method is to put in a

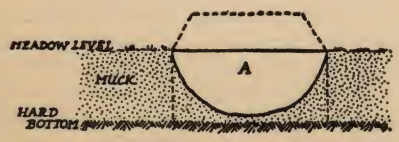


Fig. 1—When the Muck Is Shallow a Large Ditch (A) Is Blasted to Allow the Fill Material to Penetrate to Hard Bottom.

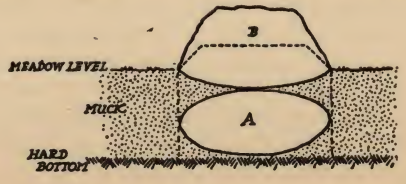


Fig. 2—When the Muck Is Deep and a Sandy Material Is Used, the Fill Is Placed on Top of the Muck; Charges Under the Fill Blast the Hole (A), and (B) Is Allowed to Settled to Hard Bottom.

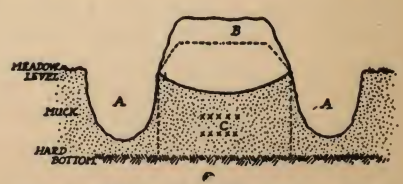


Fig. 3—When the Fill (B) Is Clay, Ditches (AA) Are Blasted to Relieve the Side Pressure, Allowing the Fill to Push Out the Muck Underneath. Sometimes Auxiliary Charges Are Exploded at (C) to Augment the Movement in Lateral Direction.

center row of holes and shoot these, allowing the material to drop along the centerline, then to shoot two parallel holes on either side of the centerline, and if necessary two more beyond that. If the fill material contains clay, it will set up a bridging effect within itself and, therefore, must be dropped for the full width of the fill at the original shooting. This means that the rows of holes will be placed across the centerline rather than parallel to it, and shot in several groups of such cross rows. The gelatin type of dynamite is used for practically all underfill shooting, but in some locations, straight nitroglycerine dynamite is used. The gelatin dynamite is recommended because of greater safety in handling.

There are many different methods of placing the charges under the fill. Well drill, wash-boring, or small pile driving outfits have been used for putting down casings. Each may be economical in a given location. Some casings have been driven in for an angle under a rock fill, keeping the casing in the unstable material all of the time. A 1½-in. pipe with a wooden plug in the bottom can be driven into place, the wooden plug pushed out, a pocket sprung, and 1¼-in. x 8-in. dynamite readily loaded into the pocket. This method is perhaps used more than any other at the present time, due primarily to the fact that smaller equipment is required to drive and to pull the casing pipe. In certain locations, a 6-in. casing is driven with a tin plate over the bottom of the casing, and 5-in. x 16-in. dynamite loaded through the casing. Every gradation of pipe and size of dynamite in between the two above has been used.

There has been some misunderstanding in the figuring of the quantity of unstable material which is removed by dynamite. For the underfill method, ¼ lb. to ½ lb. per cubic yard of unstable material to be displaced will suffice in most instances. The above figure is on the basis of the total yardage of unstable material from the swamp level to hard bottom. It has cost from 5c to 15c per pound for loading and shooting dynamite by the underfill method.

Relief Method.—The third method is known as the "Relief" method (see sketch). The idea here is to relieve the resisting pressure on the sides and underneath the fill so that the weight of the fill can carry it through to hard bottom. This is done usually by shooting side ditches after placing the fill and later shooting small charges under the fill. These charges are only to disintegrate and liquefy the soft material and are not expected to open up cavities.

The relief method of loading may be used on any depth of fill and will probably use some ditching dynamite and some of the gelatin type. It is almost impossible to figure any poundage per cubic yard for this method. Where the unstable material is very deep, and the fill has been placed, it settles to a very large degree due to its own weight. Small shots placed along the sides and under the fill will loosen the side and bottom pressure so that the weight of the fill will more readily push out this unstable liquefied material. The only recommendation that can be made in this regard is to not load too heavily, as the job is one of lubrication and disintegration, rather than to open up cavities. All side relief ditch shooting should be done by the propagation method using ditching dynamite and any underfill relief shooting should be done with a gelatin type of dynamite.

Inasmuch as every fill has individual characteristics, it is recommended that the engineer make complete soundings, developing a sub-surface profile, and then call for assistance from a competent explosive engineer. All specifications should carry a clause to the effect that trial shots, followed by soundings, must be made before a definite loading program be developed for an individual job.

How California Cares for Roadside Trees

Since 1920, civic or other public bodies of California have planted nearly 700 miles of highway roadsides to trees. This represents nearly 70,000 trees. In addition, there was about 60,000 older trees which had been planted by tree lovers making a total of 130,000 trees to be cared for by the maintenance forces of State Division of Highways. The practice in regard to these trees was outlined as follows in *California Highways and Public Works.*

The initial expense of planting and maintenance during the first year is borne by the parties interested. At the end of this period the state assumes their entire care, and replacements in event of loss.

The extent of this responsibility is appreciated when it is known that some $71,500 was expended during the past year for the care and replacement of the plantings, a sum representing 1.3 per cent of the total annual maintenance allotment.

Generally the trees are spaced at 50-ft. intervals, being placed alternately on the right and left sides of the roadway, with necessary elimination for visibility at crossings and road intersections. The care of these trees is very exacting and usually assigned to the individual foreman in whose territory they occur. Assisting in the direction of this work is the arboriculturist, reporting to the maintenance engineer.

Special tree watering equipment having a movable discharge pipe enables watering to be done from the driver's seat a tank truck of 1200 gal. usually being sufficient to water some 30 to 40 trees. This watering must be performed every four to six weeks during the period from June to October. Aside from irrigation and cultivation many precautions are necessary for the protection of young trees against insect pests, damage by squirrels, gophers, moles and loose stock driven along the highway. The hazard of fire is also great.

Particular attention is given the location of plantings to eliminate any possible interference with the ultimate development of the pavement. With this in mind, new plantings are discouraged on rights of way less than 80 ft. wide. On 80-ft. rights of way the trees are planted between the curb and right of way line, 31 ft. out from pavement center.

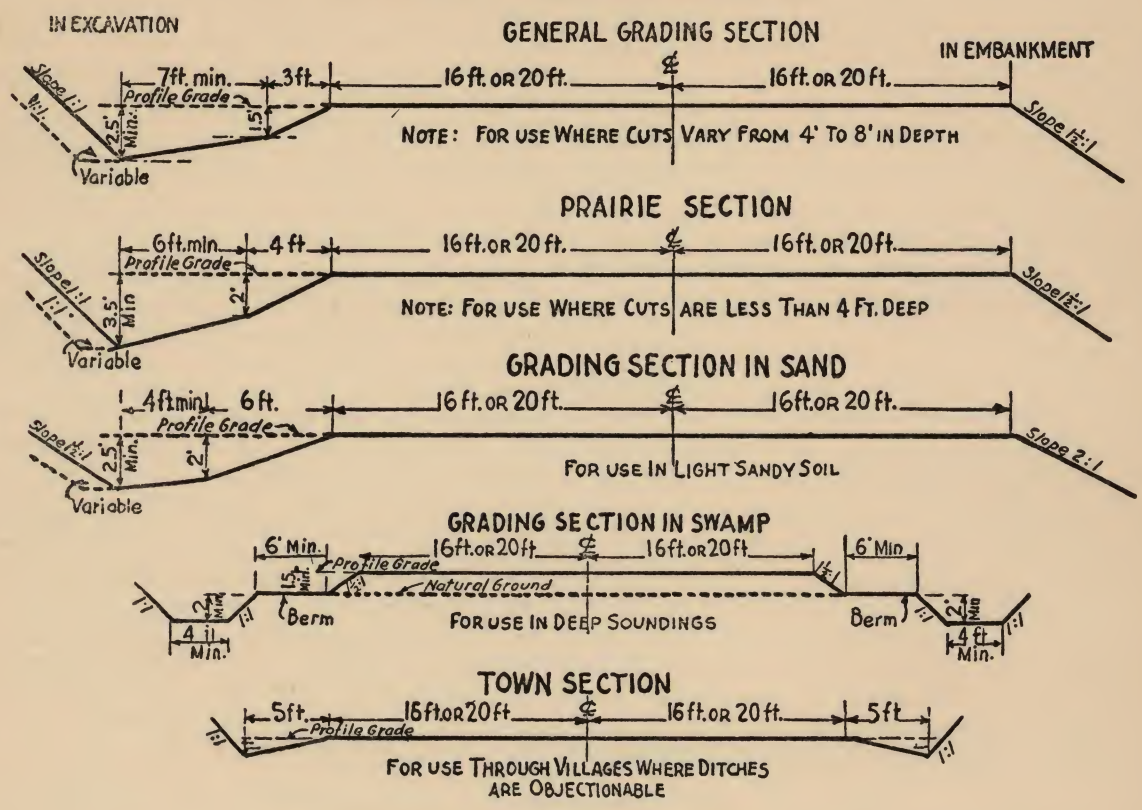
All roadside trees are inspected at intervals and particular note made of any trees within reach of the traveled way that are in any way a menace. Wherever hazard exists the trees are either removed, or trimmed and dangerous limbs cabled back to insure safety.

As load clearances require a clear height of 13½ ft. above the pavement, systematic pruning and trimming are being followed to provide this clearance and at the same time develop a symmetrical, worthwhile tree. Where power or telephone lines occur within rights of ways planted to trees, the tree height is limited to 40 ft. and all trimming for wire clearance is done by the utility company under permit and inspection of the Division of Highways.

In addition to the care of trees, the Division of Highways organization is planting shrubs and vines on cuts and fills, particularly at subways and similar structures. In many cases, this work will reduce the upkeep cost at such locations.

Things that I felt absolutely sure of a few years ago, I do not believe now; and this thought makes me see more clearly how foolish it would be to expect all men to agree with me.—F. D. Van Amburgh.

Standard Grading Sections, Minnesota State Highway Department



Sand-Clay Surface

Specifications, South Dakota State Highway Commission

Description.—This surface shall consist of a course of top soil or of a natural or artificial mixture of sand and clay having the dimensions and cross-sections shown on the plans and constructed in accordance with these specifications.

Materials.—The surfacing material shall consist of sand-clay properly proportioned by placing clay on a sand base or sand on clay base or placing both sand and clay on the subgrade.

Both the sand and clay will be obtained from the roadway, field or pits designated and approved by the Engineer. These materials will be furnished by the County, unless otherwise specified. All unsuitable materials that may overlie the acceptable material shall be stripped off and removed and the work will be measured and paid for in the same manner as specified under "Pit Stripping."

The sand-clay or top soil shall be composed of a uniform mixture of hard, durable fragments of sand together with silt and clay, and may advantageously carry a considerable amount of gravel. The mixture shall be free from an excess of feldspar or mica.

The material which will pass a 10 mesh sieve shall, when tested by A.S.T.M. Method, Designation D136-22T, meet the following requirements for grading:

	Per Cent
Clay	10 to 25
Silt	10 to 25
Total sand	50 to 80

Construction Methods.—When the subgrade has been prepared as specified under "Excavation" or "Roadway Shaping," the surfacing material shall be excavated, hauled to the road and spread on the surface to the depth and width as shown on the plans. In hauling and placing the surfacing material, the work shall be started at a point farthest from the source of supply. Hauling will not be allowed over the material placed until some has been mixed and shaped as provided for herein.

In case the sand-clay mixture as used does not contain a sufficient percentage of either sand or clay to give a durable surface, there shall be spread as much of the deficient material as the Engineer may direct and this shall be thoroughly mixed and incorporated with material previously spread. The process of mixing may require plowing to a depth of 6 or 8 inches and harrowing with a disc or tooth harrow.

After 500 to 600 feet of roadway have been thus roughly constructed, the surface shall be cut up and pulverized to a depth of 2 or 3 inches with a plow or harrow, and at the same time the shoulders on each side

of the surfaced portion of the road shall, if necessary, be sufficiently loosened to permit of a smooth, regular crown being constructed from shoulder to center of road. When the roadway has been loosened sufficiently, the surface shall be worked with a road grader or drag to the true cross-section required by the plans. This operation shall be repeated daily until the entire surface becomes smooth and firm.

Method of Measurement:

(a) Sand-Clay Surfacing. Sand-clay surfacing shall be measured by the cubic yard in truck boxes at the point of delivery on the road as specified under "Method of Measurement for Gravel Surfacing."

(b) Sand-Clay Surfacing Haul. Sand-clay surfacing haul shall be measured by the cubic yard half (½) mile as specified under "Method of Measurement for Gravel Haul."

Basis of Payment:

(a) Sand-Clay Surfacing. Sand-clay surfacing will be paid for by the cubic yard measured in truck boxes at point of delivery on the road. The contract price per cubic yard for sand-clay surfacing shall be full compensation for loosening, loading, spreading, mixing, harrowing, as well as shaping and maintaining the surface true to cross-section, until the road is accepted.

(b) Sand-Clay Surfacing Haul. Sand-clay surfacing haul will be paid for by the cubic yard one-half (½) mile for the hauling of material for the surfacing as specified under "Basis of Payment for Gravel Haul."

Traffic Bound Gravel or Crushed Stone Surface Course

Specifications, Illinois Division of Highways

Description.—This item shall consist of a wearing course of gravel or crushed stone, placed upon the completed and accepted subgrade in accordance with these specifications and in conformity with the lines, grades, and typical cross section shown on the plans.

Material.—The gravel and crushed stone shall conform to the requirements of Division III, Section 63.

Construction Methods.—The gravel or crushed stone shall be spread upon the subgrade, prepared in accordance with the requirements of Division II, Part A, Section 17. No material shall be placed upon the subgrade until it has been opened and subjected to traffic for at least thirty days. No material shall be placed when the subgrade is soft. All holes, ruts, defects or soft places occurring in the subgrade by reason of traffic or hauling over the same, or from any other cause, shall be corrected before surfacing materials are placed.

The material shall be deposited in windrows on the shoulders. The Contractor shall so space the unloading points that the required amount of material will be delivered at each 100-foot station, and he shall be responsible for its uniform distribution throughout the length of each station. On curves it shall be deposited in a windrow on the high side of the curve.

The Contractor shall, within twenty-four (24) hours after depositing the material in the windrows, spread a uniform thickness of two (2) inches over the subgrade and to the width required on the plans, unless, in the opinion of the Engineer, the condition of the subgrade is such that additional time should elapse before spreading is started.

The material shall be shaped with a blade grader while it is being compacted under traffic. The Contractor shall fill all ruts formed by traffic by dragging at least once each day, or more frequently if necessary, to prevent cutting through surfacing material into the subgrade. Holes, waves and undulations which develop and which are not filled by blading, shall be filled by adding more material from the windrows on the shoulders. The shaping of the two (2) inch thickness of surfacing material shall be continued until it is well compacted, free from ruts, waves and undulations and conforms to the cross section shown on the plans, or until accepted as provided in General Provisions, Section 9.7.

Upon acceptance of the work, the amount of material not necessary to spread and maintain the two (2) inch thickness shall be placed on the shoulders in neat symmetrical windrows. Prior to acceptance the slopes, shoulders, ditches and drainage structures shall be maintained.

Method of Measurement. — The gravel or crushed stone shall be measured for payment in cubic yards of material hauled to the work, spread and windrowed as specified herein. No allowance will be made for wastage or shrinkage which occurs during transportation to the unloading point on the subgrade.

Basis of payment.—This work shall be paid for at the contract unit price per cubic yard for "Traffic Bound Gravel or Crushed Stone Surface Course," measured as specified herein, which price shall be payment in full for furnishing all materials, loading, hauling, unloading, spreading, shaping and maintaining until accepted, and for all labor, equipment, tools and incidentals necessary to complete the work as specified herein.

Gravel and Crushed Stone for Traffic Bound Surface Courses

Specifications, Illinois Division of Highways

[These specifications comprise Section 63, referred to in the specifications for traffic bound gravel or crushed stone surface courses. The letters "A.A.S.H.O." signify American Association of State Highway Officials.]

Description.—The gravel or crushed stone shall consist of hard, strong, durable pieces; free from an excess of flat, elongated, soft or disintegrated pieces; and free from other objectionable matter.

Methods of Testing.—The material shall be tested in accordance with the following methods:

Test	Method
(a) Abrasion of Stone	A.A.S.H.O. T-3
(b) Abrasion of Gravel	A.A.S.H.O. T-4
(c) Soft Fragments	A.A.S.H.O. T-8
(d) Clay and Silt	A.A.S.H.O. T-11
(e) Specific Gravity	A.A.S.H.O. T-14; T-15
(f) Sieve Analysis	A.A.S.H.O. T-27; T-28

Methods of Sampling.—The material shall be sampled in accordance with the "Methods of Sampling Stone, Slag, Gravel, Sand and Stone Blocks for Use as Highway Materials, Including some Material-Survey Methods, Tentative Method T-2," of the A. A. S. H. O.

Requirements.—The material shall conform to the following requirements:

(a) *Wear.*—Gravel—Percentage of wear, not more than 15

Stone — Percentage of wear, not more than 8

(b) *Quantity of Clay and Silt.*—Removed by decantation, by weight, not more than..... 5.0%

(c) *Gradation.*—The material shall be well graded, between the limits specified, and shall conform to the following requirements:

(1) *Grade No. 1:*

Passing 1½-inch sieve	95-100%
Passing 1-inch sieve	75- 90%
Passing ¾-inch sieve	60- 80%
Passing ½-inch sieve	30- 45%
Passing No. 4 sieve, if gravel	15- 25%
Passing No. 4 sieve, if crushed stone	0- 15%

(2) *Grade No. 2:*

Passing 1-inch sieve	95-100%
Passing ¾-inch sieve	50- 85%
Passing ½-inch sieve	40- 65%
Passing No. 4 sieve, if gravel	15- 25%
Passing No. 4 sieve, if crushed stone	0- 15%

(3) *Grade No. 3:*

Passing ¾-inch sieve	95-100%
Passing ½-inch sieve	45- 75%
Passing No. 4 sieve, if gravel	15- 25%
Passing No. 4 sieve, if crushed stone	0- 15%

(4) *Grade No. 4:*

Passing ½-inch sieve	95-100%
Passing ⅜-inch sieve	70- 90%
Passing No. 4 sieve, if gravel	15- 25%
Passing No. 4 sieve, if crushed stone	0- 15%

(5) *Pit Run Gravel.*—Pit run gravel from commercial plants or local deposits shall not be used unless permitted by the special provisions in the contract. When permitted, pit run material shall only be used after approval by the Engineer and shall conform to specifications prepared by him to govern acceptance of the material.

Workers Set Fast Pace on Public Works Highway

What the U. S. Bureau of Public Roads believes to be a speed record in road building was established recently in the building of a Public Works highway in the San Juan National Forest in Colorado. The road, known as the Pagosa-Chama forest highway, is part of the main-traveled route between Sante Fe, N. Mex., and the Mesa Verde National Park. Only 49 days of the 200 allowed to complete this 4½-mile section of road were required to put the highway in service, according to the report of the bureau, which was in charge of the construction.

Work accomplished on the section of road built so rapidly included, grading to a 24-ft. width, building two major drainage structures of concrete, and placing two 4-in. layers of crushed surfacing material.

"This project," the report states, "proved a veritable godsend to the community, which depends on grazing, farming and lumbering for its living. Of the 276 men registered for employment in the county, 211 were given employment on the road work. This represented 6,400 men-days and 2,300 stock-days of work.

Use of Calcium Chloride in Maintaining Gravel and Macadam Roads

Following is an excerpt from a paper by H. F. Clemmer, Engineer of Materials, District of Columbia, presented at the 1933 Road School at Purdue University. The paper deals with roadway stability and the use of calcium chloride, and is abstracted at length in *Roads and Streets* for May, 1933, pages 184-186:

If maintenance manipulation is carried on while the calcium chloride solution is near the surface, the material is dissipated; however, if manipulation is carried on during or immediately after a rain, when the calcium chloride solution is some depth below the surface, the road surface may be put in the best possible condition without loss.

One value of calcium chloride is its ability to flocculate soil, that is, to cause small particles to group together into larger ones to produce a more permeable soil. This effect is important in reducing the destructive frost action. The open or permeable soil does not hold the moisture, which when freezing creates expansive forces.

Application.—Maintenance engineers regularly using calcium chloride do not believe it should be applied at any specific rate, but rather depending upon the amount of traffic carried by the road. The following table shows typical practice under general conditions:

100 to 200 vehicles per day	1 lb./sq. yd.
200 to 500 vehicles per day	1½ lb./sq. yd.
500 to 1,000 vehicles per day	2 lb./sq. yd.
1,000 and up vehicles per day	2½ lb./sq. yd.

The best practice of applying calcium chloride is to make several applications. For example, should the road require 1½ lb. per sq. yd., it would be advisable to make one application of 1 lb. per sq. yd. and follow with a second application of ½ lb. at an interval of approximately six weeks, depending upon the prevailing weather conditions.

A summary recently offered by the Maintenance Committee of the American Road Builders' Association* presents the following outline for the proper use of calcium chloride on a gravel road:

(1) Remove oversize material.

(2) Add to the gravel the constituents it lacks, either sand or clay.

(3) Scarify the surface and thoroughly mix all material added.

(4) Maintain not more than ½ in. to the foot of crown.

(5) Remove all cover and apply calcium chloride.

(6) Blade carefully after each rain and at such other times as the surface of the roadway demands it.

(7) Patch any holes with the same material as used in the entire surface.

(8) Use heavy equipment for spring work.

Conditions demanding heavier application of calcium chloride are long dry spells, heavy traffic, low clay content, recent heavy resurfacing, no shaded portions, heavy wearing cushion and dead material. Conditions favorable for lighter applications are frequent rains, light traffic, heavy clay content and shade.

The item No. 2, "Add to the gravel the constituents it lacks, either sand or clay" is one of the most important of the requirements in the outline and is being given consideration in studies of stabilization of soils. To develop a hard durable surface, the amount and type of cementing medium which will produce maximum stability must be used.

*Convention Proceedings, 1930, page 705.

Stabilization of Low Cost Roads With Calcium Chloride

R. B. Traver, County Superintendent of Highways, Onondaga County, New York, gives the following in *Roads and Streets,* issue of March, 1934:

In 1932 the Board of Supervisors of Onondaga County deemed it necessary to formulate a new plan of road construction, due to the unemployment conditions existing. The demands were, in short, a low cost construction giving maximum expenditures of money on labor and not over 10 per cent on materials; also that 1,000 men be put to work, which was three times the normal force previously employed by the county for highway purposes. After much consideration of different plans, and with foresight for the future, a method of stabilized gravel stage construction was approved, which involved putting all the care and effort into grading and drainage that had been previously put into these same items for concrete road construction. We thus developed a satisfactory, stable farm to market road, which in the future, all conditions being favorable, could easily be converted into a higher type surface, it being understood that these roads should be maintained until such time.

This plan is in accordance with the extensive development work of the Bureau of Public Roads. We may clearly define a stabilized gravel road as one that will give proper support for wheel loads, will not become slippery in wet weather, and will not ravel or become dusty in dry weather. Such a surface must combine coarse aggregate, fine aggregate, silt, clay and calcium chloride.

Preliminary Work.—Before any actual construction is started, our proposed gravel roads are surveyed for alignment, topography, and cross sections are taken. From this data the office works up new alignment, new grades, and balances the dirt. All curves 8 degrees or sharper are banked ½ in. per foot on the curve proper. We have a standard section, which is used for all our construction. It is 26 ft. between shoulders, with a ditch 28 in. in depth below center line grade. It is a known fact that our ample drainage has been an important factor in the success of our roads.

Material in the Wearing Course.—We are now ready for actual construction, and first is the clearing and grubbing work, followed by the laying of permanent, ample culverts. Then follows the ditching, the material from which is used in building our subgrade. The rough grading is completed, being bladed and rolled, if necessary, to form a stable smooth surface. Guard rail is placed at the necessary points. All the work is done by hand labor, except for any blading and rolling necessary. We are now ready for our wearing course and the best type of material would be gravel of the following composition:

50 to 60 per cent of gravel above a 10 mesh screen.

10 to 20 per cent of coarse sand above a 40 mesh screen.

10 to 20 per cent of fine sand through a 40 mesh and retained on a 270 mesh screen.

10 to 20 per cent of silt and clay through a 270 mesh screen.

The soil fines passing the No. 40 screen should have a plastic index from 8 to 12. The plastic index of a material in a measure of its ability to resist passing from a plastic state to a liquid condition by its absorption of water under certain conditions. It is expressed in percentage of water by weight that is necessary to bring about this change, or it is the difference between the liquid limit and the plastic limit. The liquid limit is the maximum amount of water expressed in percentage by weight that a sample can contain without flowing together when lightly jarred under certain conditions. The plastic limit is the minimum amount of water expressed in percentage by weight that a sample can contain and still be rolled into sticks or threads ⅛ in. in diameter. Any material which can stand this test must have considerable cohesive properties, and must contain a certain amount of clay. Now, we can state that the plastic index is the measure of the cohesive properties of a soil.

The function of the gravel is to supply rigidity and high internal friction. It also adds to the mechanical stability of the road surface. Coarse sand serves the same purpose as gravel and also locks the gravel in place. The fine sand fills the voids in the coarse sand. The silt has high capillary properties and serves as a reservoir for calcium chloride. It contributes nothing to the road's stability and has no cohesive properties, whereas the clay supplies cohesion and toughness and fills the voids completely, making the road surface impermeable. It also serves as reservoir for the calcium chloride.

Gradation plays a very important part in the materials for this class of road, and also the binder must be given consideration. However, we have not found it necessary to insist on the *close* gradations or in keeping the plastic index within the *narrow* limits in the materials at their source, and have produced excellent wearing courses without elaborate mixing.

Soil Conditions in the County.—Onondaga County covers an area of approximately 780 square miles. It is flat and sandy in the northern part, and rolling and hilly in the southern portion, with a gravely clay soil. Although gravel beds are numerous throughout the county, none of the material can be considered as ideal, it being either too coarse or to fine. Often it is without sufficient binding material to permit a good compacted wearing surface, and frequently contains an overabundance of large stones. There are also several crushed stone plants in the county, and run of crusher screenings have been used successfully in the construction of several roads.

We have found subsoil that we felt was very good, but never have we found one which met text book perfection, and this is also true with our gravel beds. However, our business is building roads, and lamenting poor conditions will not impress our Board of Supervisors. They prefer results.

Construction of Gravel Surface.—We use bank run gravel, selected mainly because of nearness to the construction. There is, however, a visual inspection supplemented by simple field tests, and in a few cases where there was more than one bed in close proximity, an analysis has determined the choice of beds. The gravel is loaded on the trucks by a shovel and hauled to the job where it is rough spread by the tail board of the trucks. The gravel is then spread to a 9-in. depth at the center, 6-in. depth 5 ft. from the center, and to a feather edge 10 ft. from the center, giving a 20-ft. gravel surface.

The large stones are removed from the surface by raking, and the surface is shaped by blading, followed by rolling and honing, filling depressions and cutting off humps. The riding qualities are built into the road at this stage. This rolling is done from the edges toward the center, and after a thorough compaction the road is

opened to traffic for a period of from 10 days to two weeks. During this time, if there are any unfavorable peculiarities or characteristics of the gravel, they will show themselves, and we must correct them.

Remedying Unfavorable Conditions.—The most frequent unfavorable conditions are an excess of coarse material, which may be gravel with low binding properties, and that of having an abundance of fine material or a surface with too much clay, which causes a slippery road. The first condition is remedied by blading or scraping some of the shoulder dirt over the surface of the gravel, or by placing a layer of shale sand on the surface which weathers, giving a clay binder. The clay condition is corrected by spreading the road surface with 1 to 1½ in. of limestone chips, or with a clean sand. By these two remedies, we have been able to correct practically all of our difficulties.

Use of Crusher Run Stone.—In one or two instances, where we have not been able to procure any gravel, we have resorted to the use of crusher run from a nearby stone quarry. This product contains soil, dust, screenings, and No. 1, 2, and 3-A stone. In each case we predetermined the qualities which were lacking by a thorough examination and were able to supply the necessary material from the road subgrade. Sufficient of the latter material was windrowed along both sides of the road, so that when the crusher run was spread on the subgrade we were able to bring the soil on top by the use of graders, and to thoroughly mix these materials with drags or harrows. These simple operations were sufficient to produce a product which met all the requirements of a stabilized material. For our standard section we use 1,711 cu. yd. of gravel per mile of road. Where crusher run was used, only about 800 tons per mile were placed at a cost of 15 ct. per ton in our trucks.

Treatment with Calcium Chloride.—Our road surface is now a smooth, compact tread, and from all visual appearances, a stable satisfactory surface. However, should traffic be permitted to use the surface for any extended length of time, the condition would soon result in a rutty, unstable, dusty road. The surface must be kept moist to give satisfactory service. We accomplish this by a treatment of calcium chloride, spreading it with an ordinary lime spreader drawn by truck. We spread 1½ lb. per square yard, or 8.8 tons per mile, the center strip receiving a heavier application due to the greater depth of gravel.

We find that it is not necessary to wait for favorable conditions of moisture or dryness to apply the calcium. The average daily mileage per truck is about 5 miles of complete surfacing. The average cost of the initial treatment of our roads is $240 per mile. Our complete stabilized treated wearing course costs from $1,750 to $2,250 per mile.

The action of the calcium chloride is to supply the needed moisture necessary to bind the soil fines into a well compacted stable surface. In wet weather, the chloride is driven farther into the wearing course, and is utilized in the dry periods following, coming to the surface by capillary action. It is very hygroscopic, absorbing the atmosphere, and its presence in the soil reduces evaporation from the surface. Our grades have run as high as 10 per cent and over, and the gravel is held just as firm as on the level surfaces with no indications of erosion or raveling.

Maintenance Methods.—As yet it has not been necessary to add maintenance gravel. Our maintenance consists of honing the surface as required, and retreating the surface with calcium chloride once or twice each year. We have found that one pound per square yard applied in the spring and from ¾ to 1 lb. applied during the summer is sufficient. Honing is usually done following rains, so as not to waste chloride. We find that infrequent honing, possibly two or three times a year, is all that is necessary for the majority of our roads. However, on some roads, where the travel is in excess of 800 vehicles per day, it is necessary to hone the surface about every four weeks. Honing is a small item in the maintenance cost. Our general spring scraping is done with an Austin No. 77 Grader. It will cover 5 miles of surface per day at a cost of less than $5 per mile. After this, any honing done during the rest of the season is with a truck, using the rut scraper as the blade. We do not maintain a floating surface or a loose mulch, and for this reason it is not necessary to give the surface the daily maintenance usually given to gravel roads. Present indications are that additional gravel will not be necessary for several years, as the loss from the surface is very small.

In 1932, we constructed 50 miles of stabilized gravel roads. This construction was so satisfactory that the 1933 program was wholly concentrated to this gravel type road, so that by the end of 1933 a total of 335 miles had been completed. Many of these roads will be maintained as satisfactory farm to market roads. Others will prove to be important thoroughfares in the future and warrant a concrete surface. In such an event, the stabilized, well compacted wearing course will form an ideal subgrade for such a structure, so that a thinner concrete slab may be used.

Employment on Public Roads

According to the January Trend of employment bulletin of the U. S. Department of Labor 169,417 men were employed in the construction and maintenance of state and public roads in January, 1934.

Due to weather conditions there was a decrease in the number of employes working on state highways, comparing January 1934 with December 1933, of 13.8 per cent. Pay rolls for these workers also decreased 15.1 per cent. Of the workers engaged on state roads, 84.6 per cent were engaged in maintenance work and 15.4 per cent in the construction of new roads.

Table I shows the number of employes engaged in the construction and maintenance of State and Federal public roads, by months, January to December 1933.

Table I.—Number of Employes Engaged in Construction and Maintenance of Public Roads, State and Federal January to December 1933*

Month	Number of employes working on— Federal roads	State roads New	State roads Maintenance	Total
January	74,405	39,906	150,989	190,895
February	76,969	36,352	140,639	176,991
March	95,491	37,891	145,559	183,450
April	121,089	40,560	136,996	177,556
May	138,934	47,540	142,713	190,253
June	151,614	54,388	152,855	207,243
July	128,801	61,428	141,558	202,986
August	106,907	60,365	158,159	218,524
September	79,980	62,366	160,492	222,858
October	56,872	58,711	171,260	229,971
November	38,112	63,379	170,765	234,144
December	21,345	46,810	140,813	187,623

*Excluding employment furnished by projects financed from the public works fund.

The peak of employment on Federal roads, other than those financed from the public works fund, was reached in June, when 151,614 people were working under the regular Federal highway appropriation.

Waterbound Macadam Base Course

Specifications, Illinois Division of Highways

Description.—This item shall consist of a foundation course of crushed stone and screenings, constructed on the prepared subgrade in accordance with these specifications, and conforming in all respects with the line, grade, thickness, and typical cross section shown on the plans. When the cross section calls for a compacted thickness of more than four (4) inches, the base course shall be constructed in two layers of equal thickness.

Materials.—All materials shall conform to the requirements specified in Division III, Material Details. Specific references to Division III are as follows:

	Section	Article
(a) Crushed Stone	60	60.1-60.4
(b) Stone Screenings	60	60.1-60.4

Construction Methods. — The subgrade shall be prepared in accordance with the requirements of Division II, Part A, Section 17, Subgrade. No coarse material shall be placed until the screenings for filling the same have been uniformly distributed in neat piles along the side of the highway.

(a) *Spreading Coarse Aggregate.*—Where no curbs are used, side forms and either cubical blocks of wood or center guide forms of the height of the loose material shall be used for each course. The side forms shall be set true to line and grade and shall be securely staked, after which they shall be backed with earth or other suitable material on the berm side to a width of not less than eighteen (18) inches and to such height that, after being thoroughly compacted, the backing will conform to the height of the compacted course.

Any ruts, holes, defects, or soft yielding places which occur in the subgrade, by reason of any improper drainage conditions, traffic or hauling over the same, or from any other cause, shall be corrected and rolled until firm before the coarse aggregate is placed thereon. No coarse aggregate shall be spread on a wet or frozen subgrade, nor more than an average day's work in advance of rolling and filling.

The crushed stone shall be evenly spread on the subgrade to such depth that when compacted it shall have the thickness shown on the plans. Spreader boxes of an approved design shall be used, unless special permission to use other means is granted by the Engineer. After the crushed stone has been spread and before rolling, the side forms shall be removed and the space between the aggregate and the earth backing shall be filled with earth to such height as will compact to the final thickness of the course. To produce a uniform and even distribution, the crushed stone shall be harrowed with a heavy straight-toothed harrow of approved design. The crushed stone as spread shall be well graded, shall have no pockets of fine materials, and shall be so handled that there will be no segregation of fine or coarse particles.

(b) *Rolling and Filling.* The crushed stone shall be rolled with a self-propelled, three-wheel roller weighing not less than ten (10) tons. The rolling shall begin at the edges of the course, and the outside driver of the roller shall cover equal parts of aggregate and shoulder. The roller shall be run forward and backward along the edge until the shoulder and crushed stone are bound together firmly. When the sides have been firmly rolled, the rolling shall progress gradually toward the center, parallel with the centerline of the roadway, uniformly lapping each preceding track and covering thoroughly the entire surface with the rear wheels, and continuing until the stone does not creep or wave ahead of the roller. Where superelevated curves are encountered, the rolling shall begin at the edges of the course as heretofore specified and continue until the crushed stone and shoulders are firmly bound together. It shall then be continued from the inner edge of the curve to the outer edge, instead of from the edges of the center as heretofore specified. If any irregularity exceeding three-fourths (¾) of an inch, when tested with a 10-foot straight edge, develops during the rolling, the crushed stone shall be loosened, refilled with new material and again rolled as required above.

After the crushed stone has been thoroughly rolled and keyed, screenings shall be applied gradually over the surface during the finishing process of dry rolling in such amounts as will completely fill the interstices. The screenings shall not be dumped on the surface of the aggregate, but shall be spread in thin layers from the piles at the roadside. The rolling shall continue while the screenings are being spread to aid in settling them to the bottom. The screenings shall not be allowed to cake or bridge on the surface of the aggregate in such manner as to prevent the perfect filling of voids and the direct bearing of the roller on the face of the aggregate. The screenings shall be swept in with hand brooms to properly fill the voids. The spreading and rolling shall continue until no more screenings will go in dry. No excess of screenings shall be used before applying water.

(c) *Finishing.*—Immediately after the voids have been filled with screenings, the macadam shall be sprinkled until saturated, the sprinkler being followed by the roller. More screenings shall be added if necessary. The sprinkling, sweeping and rolling shall continue until a grout shall be formed of the screenings and water that will fill all voids and form a wave of grout before the wheels of the roller. The quantity of screenings and water necessary shall be determined by the Engineer and shall be sufficient only to produce a rough, granular surface. The rolling at all times shall begin at the sides, overlapping the shoulders and progress toward the center, thoroughly covering the entire surface with the rear wheels.

Should the subgrade become soft and mixed through this course, the Contractor shall, without additional compensation, remove the mixture, reshape and compact the subgrade, and replace the materials removed with clean aggregate which shall be rolled, broomed and filled until compacted satisfactorily and uniformly with the surrounding surface.

The process of water binding shall be prosecuted in sections not to exceed five hundred (500) feet in length and each section shall be completed to the satisfaction of the Engineer before another section is started. When a section has been thoroughly filled and grouted as described above, it shall be left to dry out before it shall be opened to travel, but the surface shall be maintained until the entire highway has been accepted.

The finished surface of the course shall not vary more than three-fourths (¾) of an inch from a 10-foot straightedge applied to the surface parallel to the center of the pavement.

Basis of Payment.—This work shall be paid for at the contract unit price per square yard for "Waterbound Macadam Base Course," measured in place, which price shall be payment in full for furnishing all materials, equipment, tools and labor, and constructing the base course complete as specified herein.

Waterbound Macadam Surface Course

Specifications, Illinois Division of Highways

Description.—This item shall consist of a wearing course of crushed stone and screenings, constructed on the prepared base course in accordance with these specifications, and conforming in all respects with the line, grade, thickness, and typical cross section shown on the plans.

Materials.—All materials shall conform to the requirements specified in Division III, Material Details. Specific references to Division III are as follows:

Item	Section	Article
(a) Crushed Stone	60	60.1-60.4
(b) Stone Screenings	60	60.1-60.4

Construction Methods.—No coarse material shall be placed until the screenings for filling the same have been uniformly distributed in neat piles along the side of the highway.

(a) *Spreading Coarse Aggregate.*—Where no curbs are used, side forms and either cubical blocks of wood or center guide forms of the height of the loose material shall be used for each course. The side forms shall be set true to line and grade and shall be securely staked, after which they shall be backed with earth or other suitable material on the berm side to a width of not less than eighteen (18) inches and to such height that, after being thoroughly compacted, the backing will conform to the height of the compacted course. The prepared base shall be thoroughly cleaned of all foreign substances and the crushed stone shall be evenly spread upon it to such depth that when compacted it shall have the thickness shown on the plans. Spreader boxes of an approved design shall be used, unless special permission to use other means is granted by the Engineer. After the crushed stone has been spread and before rolling, the side forms shall be removed and the space between the aggregate and the earth backing shall be filled with earth to such height as will compact to the final thickness of the course. To produce a uniform and even distribution, the crushed stone shall be harrowed with a heavy straight-toothed harrow of approved design. Any thin, flat or oversize stones that appear on the surface during construction shall be removed. Special care shall be taken to have uniform material in the surface. All patches of fine material appearing in this course shall be removed and replaced with suitable material before final filling and water binding.

(b) *Rolling and Filling.*—The crushed stone shall be rolled with a power-driven three-wheeled roller weighing not less than ten (10) tons. The rolling shall begin at the edges of the course, and the outside driver of the roller shall cover equal parts of aggregate and shoulder. The roller shall be run forward and backward along the edge until the shoulder and crushed stone are bound together firmly. When the sides have been firmly rolled, the rolling shall progress gradually toward the center, parallel with the centerline of the roadway, overlapping on successive trips by at least one-half the width of the rear roll, until the entire surface has been covered, and until the stone does not creep or wave ahead of the roller. Where superelevated curves are encountered, the rolling shall begin at the edges of the course as heretofore specified and continue until the crushed stone and shoulders are firmly bound together. It shall then be continued from the inner edge of the curve to the outer edge, instead of from the edges to the center as heretofore specified. If any irregularity exceeding three-fourths (¾) of an inch, when tested with a 10-foot straight edge, develops during the rolling, the crushed stone shall be loosened, refilled with new material and again rolled as required above. After the crushed stone has been thoroughly rolled and keyed, screenings shall be applied gradually over the surface during the finishing process of dry rolling in such amounts as will completely fill the interstices. The screenings shall not be dumped on the surface of the aggregate, but shall be spread in thin layers from the piles at the roadside. The rolling shall continue while the screenings are being spread to aid in settling them to the bottom. The screenings shall not be allowed to cake or bridge on the surface of the aggregate in such manner as to prevent the perfect filling of voids and the direct bearing of the roller on the face of the aggregate. The screenings shall be swept in with hand brooms to properly fill the voids. The spreading and rolling shall continue until no more screenings will go in dry. No excess of screenings shall be used before applying water.

(c) *Finishing.*—Immediately after the voids have been filled with screenings, the macadam shall be sprinkled until saturated, the sprinkler being followed by the roller. More screenings shall be added if necessary. The sprinkling, sweeping and rolling shall continue until a grout shall be formed of the screenings and water that will fill all voids and form a wave of grout before the wheels of the roller. The quantity of screenings and water necessary shall be sufficient to produce a smooth, hard, monolithic surface. The process of water binding shall be prosecuted in sections not to exceed 500 feet in length and each section shall be completed to the satisfaction of the Engineer before another section is started. When a section has been thoroughly filled and grouted as described above, it shall be left to dry out before it shall be opened to travel, but the surface shall be maintained until the entire highway has been accepted. The finished surface of the course shall not vary more than one-half (½) of an inch from a 10-foot straight edge applied to the surface parallel to the centerline of the pavement.

Basis of Payment.—This work shall be paid for at the contract unit price per square yard for "Waterbound Macadam Surface Course," measured in place, which price shall be payment in full for furnishing all materials, equipment, tools and labor, and constructing the surface course complete as specified herein.

Crushed Stone and Screenings for Waterbound Macadam Base and Surface Courses

Specifications, Illinois Division of Highways

[These specifications comprise Articles 60.1-60.4, referred to in the specifications for waterbound macadam base and surface courses. The letters "A.A.S.H.O." signify American Association of State Highway Officials.]

Description.—The crushed stone shall consist of clean, tough, durable fragments, free from an excess of flat, elongated, soft or disintegrated pieces. Screenings shall be free from dirt or other foreign materials.

Methods of Testing. — The crushed stone shall be tested in accordance with the following methods:

Test	Method
(a) Abrasion	A.A.S.H.O. T-3
(b) Sieve Analysis	A.A.S.H.O. T-27; T-29

Methods of Sampling.—The crushed stone and screenings shall be sampled in accordance with "Methods of

Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including some Material-Survey Methods, Tentative Method T-2," of the A. A. S. H. O.

Requirements.—The crushed stone and screenings shall conform to the following requirements:

(a) *Wear.*—Percentage of wear, not more than 7.0.

(b) *Gradation of Crushed Stone.*—The crushed stone shall be well graded, between the limits specified, and shall conform to the following requirements:

Passing 3-inch sieve 100%
Passing 1½-inch sieve 0- 10%

(c) *Gradation of Screenings.*—The stone screenings shall be well graded, between the limits specified, and shall conform to the following requirements:

Passing ¾-inch sieve 100%
Passing No. 10 sieve 30- 70%
Passing No. 100 sieve 0- 15%

Gravel Surface Course

Specifications, Vermont State Highway Department

Description.—This item shall consist of a wearing course composed of gravel, and shall be constructed on the prepared subgrade, or completed base course, in accordance with these Specifications and in conformity with the lines, grades, compacted thickness, number of component courses, and typical cross-section shown on the Plans.

Materials.—The gravel shall be hard, durable rock together with the sand and clay or other approved binding material and shall be free from thin or elongated pieces. It shall be of such sizes for top course that all will pass through a 1 inch circular opening, and not less than 35 per cent be retained on a ¼ inch screen and of such sizes for bottom course that all will pass through a 3½ inch circular opening, and not less than 40 per cent be retained on a ¼ inch screen and for either course, it shall be uniformly graded. The finer material shall consist of sand and clay or other binding material approved by the Engineer. Should the "run of the bank" for any reason or at any time during the work fail to maintain suitable proportions of coarse and fine particles, or should the coarse particles not be uniformly graded between the maximum and minimum sizes as specified, it shall be screened, or manipulated in such a manner as to furnish a material meeting the above requirements. If the "run of the bank" is too fine, it shall be screened in such a manner as to remove sufficient fine material to make the product meet the above requirements, or coarse material from some other source shall be added to get the same results. If the "run of the bank" contains 10 per cent or more coarse materal not passing a 3½ inch circular opening, the whole material from the bank shall, if required by the Engineer, be passed through a crusher whose jaws are adjusted in such a way as to get a product meeting the above requirements for the percentages of coarse and fine material, but the maximum size of the product shall be such that all will pass a 1 inch circular opening for the top course and a 3 inch circular opening for the bottom course.

Method of Construction.—The gravel shall be laid in two courses unless otherwise shown on the Plans. After the subgrade or fundation course shall have been properly prepared and proper drainage provided, the gravel shall be spread evenly by means of approved spreader wagons or trucks or from dumping platforms and the loads shall be so dumped that the entire load will be rehandled to put it in place so that it will have, after compacting, the required thickness. No segregation of large or fine particles shall be allowed, but the gravel as spread shall be well graded, with no pockets of fine material. The gravel after being placed shall be so manipulated as to be thoroughly compacted, and any depressions, that may appear shall be filled and again compacted. After the bottom course has been properly laid and rolled or otherwise satisfactorily compacted, the top course may be spread and compacted to a thickness as shown on the Plans or ordered by the Engineer.

Method of Measurement.—This item shall be measured by the cubic yard compacted complete in place. No allowance will be made for material forced into the subgrade, and the dimensions used for thickness will not exceed those shown on the Plans or ordered by the Engineer.

Basis of Payment.—The quantity to be paid for under this item shall be the number of cubic yards of compacted material in place complete. The price bid shall cover the furnishing, placing, filling and compacting of the material and all labor and incidental expenses necessary to complete the work.

Waterbound Macadam

Spread of Stone

From Road and Pavement Data Book of the Amiesite Asphalt Co.

Kind	Wt. Per Cu. Yd.	Spread, Loose Fill, Sq. Yds. Per Cu. Yd. 2-in.	3-in.	4-in.	5-in.	6-in.	7-in.	8-in.
Granite	2,845	18	12	9	7.2	6	5.1	4.5
Limestone	2,845	18	12	9	7.2	6	5.1	4.5
Sandstone	2,511	18	12	9	7.2	6	5.1	4.5
Trap	3,095	18	12	9	7.2	6	5.1	4.5

Based Upon 38 Per Cent Voids

Kind	Cu. Ft. Per Ton	Spread, Loose Fill, Sq. Yds. Per Ton 2-in.	3-in.	4-in.	5-in.	6-in.	7-in.	8-in.
Granite	18.98	12.65	8.44	6.33	5.05	4.22	3.62	3.16
Limestone	18.98	12.65	8.44	6.33	5.05	4.22	3.62	3.16
Sandstone	21.5	14.33	9.56	7.17	5.73	4.78	4.10	3.58
Trap	17.45	11.63	7.76	5.82	4.76	3.88	3.32	2.90

Approximate Amount of Filler Required for Crushed Stone Macadam Bottom Course, Using 0.35 Cu. Yd. Filler Per Cu. Yd. Rolled Bottom

From Harger's Rural Highways

Width Macadam Ft.	Rolled Depth of Bottom Course 3-in.	4-in.	5-in.	6-in.
	Cubic Yards per 100 Ft. of Road			
10	3.2	4.3	5.4	6.6
12	3.8	5.1	6.5	7.6
14	4.5	6.0	7.5	9.0
15	4.9	6.4	8.0	9.0
16	5.2	6.9	8.6	10.4
18	5.9	7.9	9.7	11.8
20	6.4	8.6	10.8	12.8
22	7.0	9.4	11.8	14.2

Waterbound Macadam

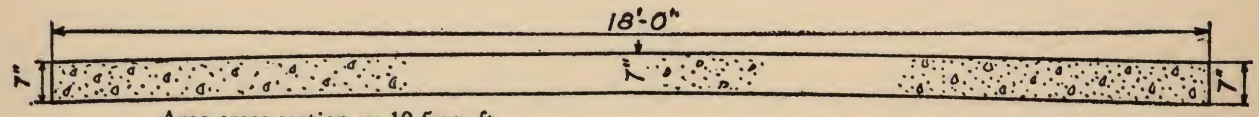
Quantities for Estimating Purposes

Width Ft.	Thickness In.	Cubic Yards Per Mile. Cu. Yd.	Width Ft.	Thickness In.	Cu. Yd.	Sq. Yds.	Cubic Yards Per 1,000 to 20,000 Sq. Yds. Thickness—Inches— 4	5	6	7	8	9
9	2	293	16	2	522	1000	111	139	167	194	222	250
9	2½	367	16	2½	652	2000	222	278	333	389	444	500
9	3	440	16	3	782	3000	333	417	500	583	667	750
9	4	587	16	4	1043	4000	444	556	667	778	889	1000
9	6	880	16	6	1564	5000	556	694	833	972	1111	1250
9	7	1027	16	7	1825	6000	667	833	1000	1167	1333	1500
9	8	1173	16	8	2086	7000	778	972	1167	1361	1556	1750
9	9	1320	16	9	2347	8000	889	1111	1333	1556	1778	2000
15	2	489	20	2	652	9000	1000	1250	1500	1750	2000	2250
15	2½	611	20	2½	815	10000	1111	1389	1667	1944	2222	2500
15	3	733	20	3	978	12000	1333	1667	2000	2333	2667	3000
15	4	978	20	4	1304	14000	1556	1944	2333	2722	3111	3500
15	6	1467	20	6	1956	16000	1778	2222	2667	3111	3555	4000
15	7	1711	20	7	2281	18000	2000	2500	3000	3500	4000	4500
15	8	1956	20	8	2607	20000	2222	2778	3333	3889	4444	5000
15	9	2200	20	9	2933							

Concrete Pavements

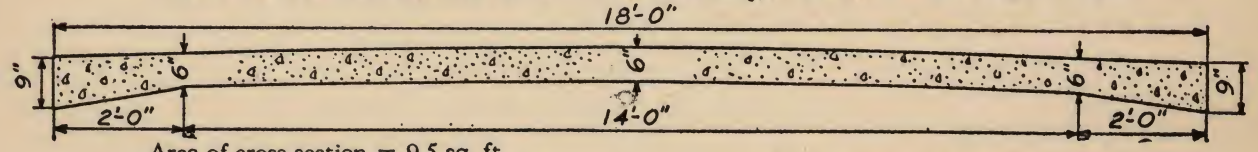
Materials Required Per Lineal Foot, Per Mile and Per Cubic Yard for Various Mixes and Sections

Compiled by the Portland Cement Association



Area cross section = 10.5 sq. ft.
Cu. yd. of concrete per lin. ft. = .389

			Cu. yd. per mile =	2053.92 cu. yd.
Cement	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.743 bbl.	For one mile =	3907.2 bbl.
Sand	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.163 cu. yd.	For one mile =	862.6 cu. yd.
Stone	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.331 cu. yd.	For one mile =	1747.7 cu. yd.
Cement	for 1 lin. ft. of concrete 1 : 2 : 3 =	.677 bbl.	For one mile =	3574.6 bbl.
Sand	for 1 lin. ft. of concrete 1 : 2 : 3 =	.202 cu. yd.	For one mile =	1066.6 cu. yd.
Stone	for 1 lin. ft. of concrete 1 : 2 : 3 =	.299 cu. yd.	For one mile =	1578.7 cu. yd.



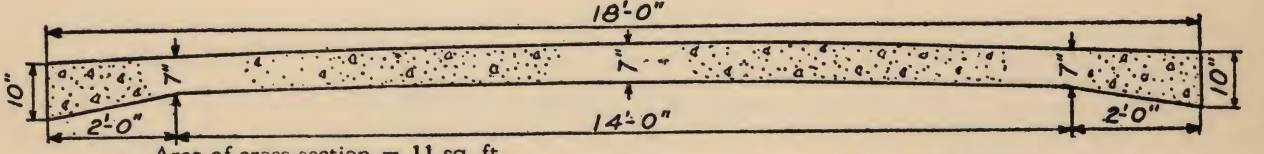
Area of cross section = 9.5 sq. ft.
Cu. yd. of concrete per lin. ft. = .352

			Cu. yd. per mile =	1858.6 cu. yd.
Cement	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.672 bbl.	For one mile =	3548.2 bbl.
Sand	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.148 cu. yd.	For one mile =	781.4 cu. yd.
Stone	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.299 cu. yd.	For one mile =	1578.7 cu. yd.
Cement	for 1 lin. ft. of concrete 1 : 2 : 3 =	.612 bbl.	For one mile =	3231.4 bbl.
Sand	for 1 lin. ft. of concrete 1 : 2 : 3 =	.183 cu. yd.	For one mile =	966.2 cu. yd.
Stone	for 1 lin. ft. of concrete 1 : 2 : 3 =	.271 cu. yd.	For one mile =	1430.9 cu. yd.

Cement for 1 cu. yd. of concrete { 1 : 1½ : 3 Mix. = 1.91 bbl. / 1 : 2 : 3 Mix. = 1.74 bbl.

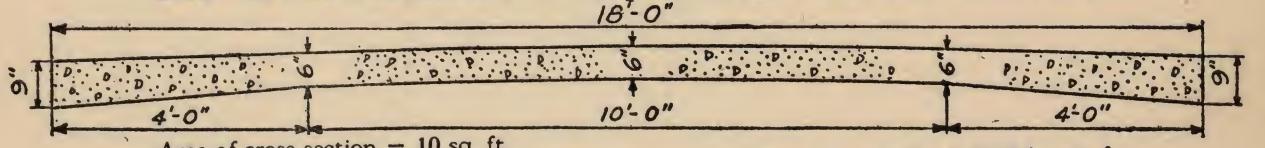
Sand for 1 cu. yd. of concrete { 1 : 1½ : 3 Mix. = 0.42 cu. yd. / 1 : 2 : 3 Mix. = 0.52 cu. yd.

Stone for 1 cu. yd. of concrete { 1 : 1½ : 3 Mix. = 0.85 cu. yd. / 1 : 2 : 3 Mix. = 0.77 cu. yd.



Area of cross section = 11 sq. ft.
Cu. yd. concrete per lin. ft. = .407

			Cu. yd. per mile =	2149.0 cu. yd.
Cement	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.777 bbl.	For one mile =	4101.6 bbl.
Sand	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.171 cu. yd.	For one mile =	902.9 cu. yd.
Stone	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.346 cu. yd.	For one mile =	1826.9 cu. yd.
Cement	for 1 lin. ft. of concrete 1 : 2 : 3 =	.708 bbl.	For one mile =	3738.2 bbl.
Sand	for 1 lin. ft. of concrete 1 : 2 : 3 =	.212 cu. yd.	For one mile =	1119.4 cu. yd.
Stone	for 1 lin. ft. of concrete 1 : 2 : 3 =	.313 cu. yd.	For one mile =	1652.6 cu. yd.



Area of cross section = 10 sq. ft.
Cu. yd. of concrete per lin. ft. = .370

			Cu. yd. per mile =	1953.6 cu. yd.
Cement	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.707 bbl.	For one mile =	3733.0 bbl.
Sand	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.155 cu. yd.	For one mile =	818.4 cu. yd.
Stone	for 1 lin. ft. of concrete 1 : 1½ : 3 =	.315 cu. yd.	For one mile =	1663.2 cu. yd.
Cement	for 1 lin. ft. of concrete 1 : 2 : 3 =	.644 bbl.	For one mile =	3400.3 bbl.
Sand	for 1 lin. ft. of concrete 1 : 2 : 3 =	.192 cu. yd.	For one mile =	1013.8 cu. yd.
Stone	for 1 lin. ft. of concrete 1 : 2 : 3 =	.285 cu. yd.	For one mile =	1504.8 cu. yd.

Cement for 1 cu. yd. of concrete { 1 : 1½ : 3 Mix. = 1.91 bbl. / 1 : 2 : 3 Mix. = 1.74 bbl.

Sand for 1 cu. yd. of concrete { 1 : 1½ : 3 Mix. = 0.42 cu. yd. / 1 : 2 : 3 Mix. = 0.52 cu. yd.

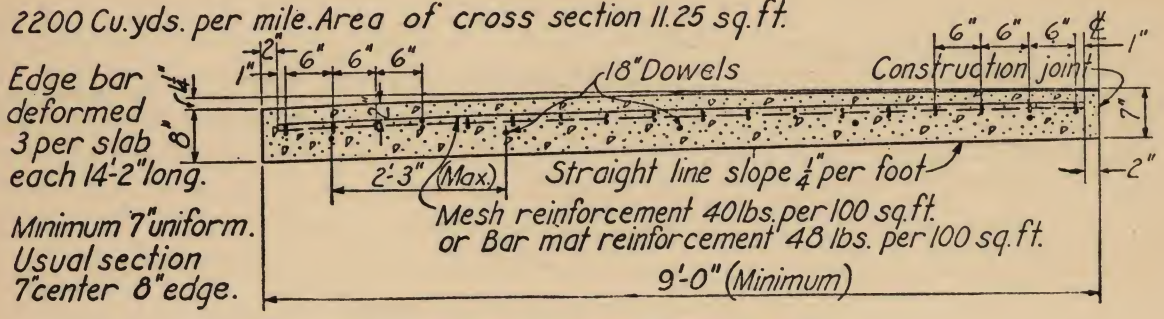
Stone for 1 cu. yd. of concrete { 1 : 1½ : 3 Mix. = 0.85 cu. yd. / 1 : 2 : 3 Mix. = 0.77 cu. yd.

Based on 1 bbl. cement equal 4 cu. ft.; voids in stone, 45 per cent.
Factors used from Taylor and Thompson: "Concrete, Plain and Reinforced."

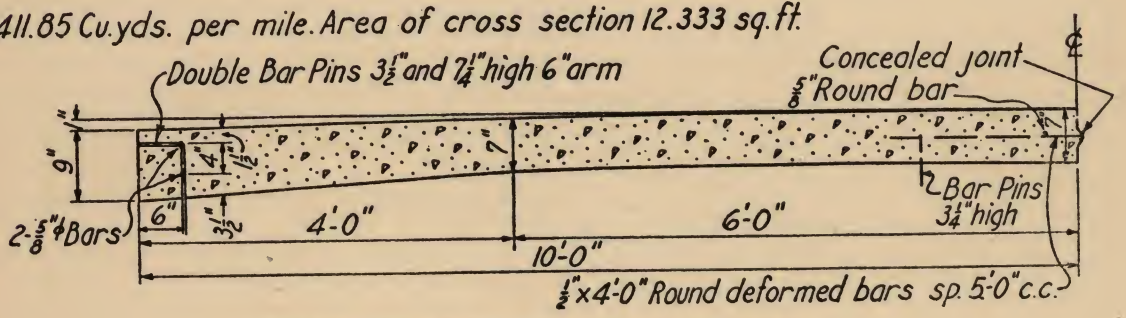
Concrete Pavements

Typical Cross-Sections of Various States

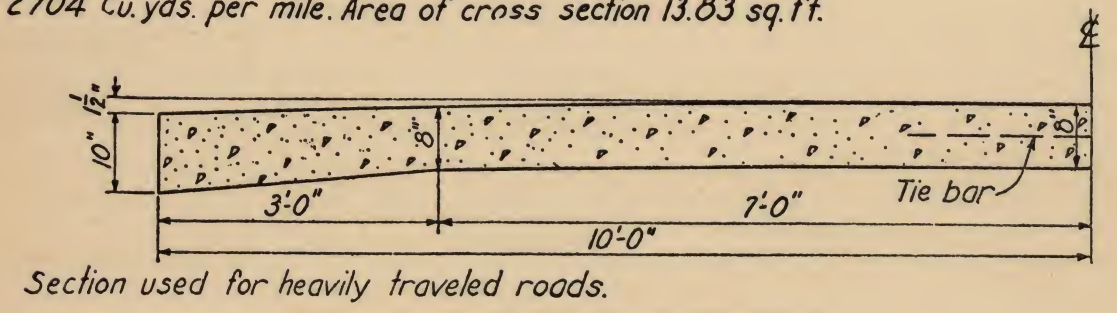
Courtesy of Portland Cement Association



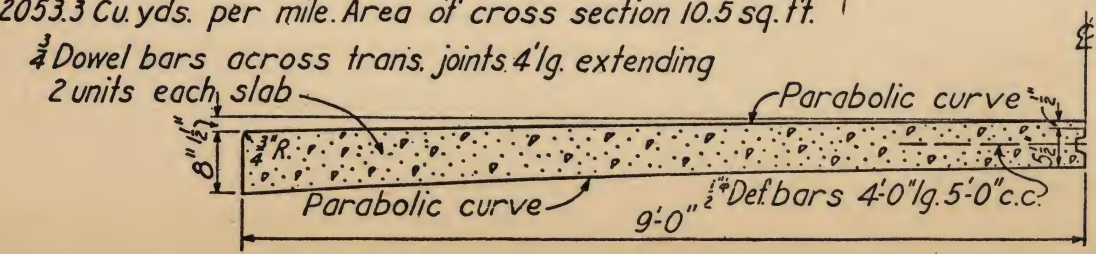
New York State Highway Department Concrete Pavement



Minnesota State Highway Department Concrete Pavement



Michigan State Highway Department Concrete Pavement

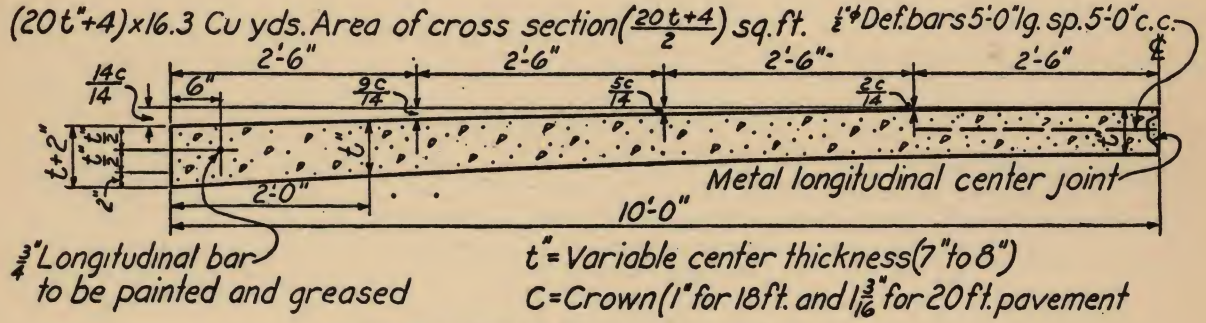


Tennessee State Highway Department Concrete Pavement

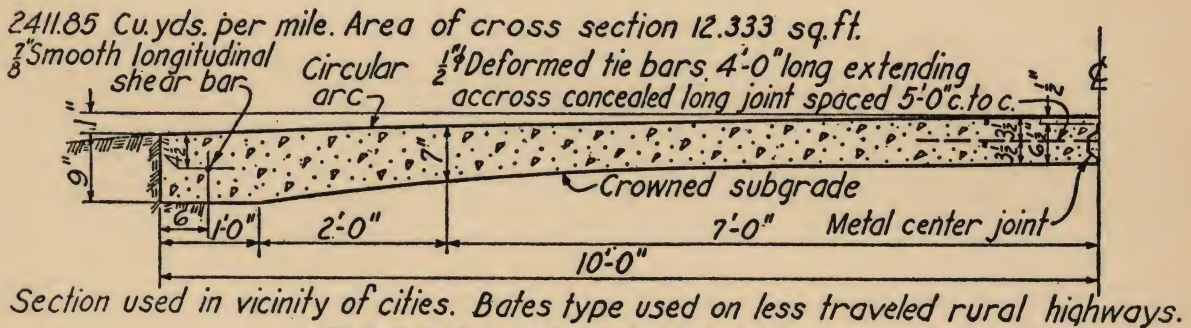
Concrete Pavements

Typical Cross-Sections of Various States

Courtesy of Portland Cement Association

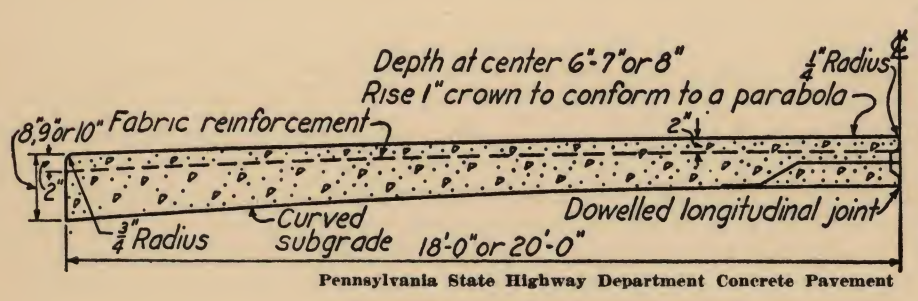


Ohio State Highway Department Concrete Pavement



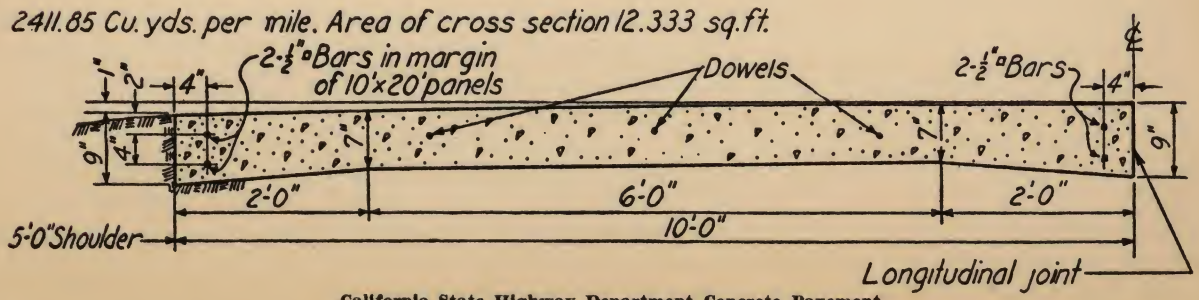
Section used in vicinity of cities. Bates type used on less traveled rural highways.

Illinois State Highway Department Concrete Pavement



Size	Width of Roadwy	Volume Cu.yds. Per Mile
8x6x8	16'	1738
8x6x8	18'	1956
9x7x9	18'	2249
9x7x9	20'	2499
10x8x10	18'	2542
10x8x10	20'	2824

Pennsylvania State Highway Department Concrete Pavement



California State Highway Department Concrete Pavement

A Charted Summary of Concrete Road Specifications of

Courtesy of Portland Cement Association

STATE	General type of cross section used		MATERIALS																		
			FINE AGGREGATE								COARSE AGGREGATE										
			Grading Specified										Grading Specified								
			Percentage passing each sieve (By weight)						Colorimetric tests	Elutriation test Max. % of silt (By weight)	Abrasion Maximum Percent Wear	Soundness test	Percentage passing each sieve (By weight)							Separated sizes required	Use of Bulk Cement
	Thickness	Width	1/4"	No 8	No 20 Max.	No 30 Max.	No 50 Max.	No 100 Max.					2 1/2"	2"	1 1/2"	1" Max.	3/4" Max.	1/2" Max.	1/4" Max.		
COLUMN No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
ALABAMA	9-6-9	20'	95-100	85-100	#16 50-80		5-30	0-5	R	—	Slag 7 Stone 6	R	3 Sizes	97-100	97-100	40-70 97-100	40-70	40-70	0-5 0-7 0-10		C
ARIZONA	9-6-9		95-100			25-50		0-5	R	3	12-18		95-100		1 1/2" 25-75				5		
ARKANSAS	9-6-9	18'-20'	85-100	F.M. 2.30 to 3.75		40-60		0-5	R	3	Stone 6 Gravel 15	R	3" 100	Fineness Modulus 1.10 to 8.10					0-5	R(2)@1 1/2"	θ
CALIFORNIA	*9-7-9-7-9	20'	#3 90-100	#10 55-80	30-55	20-35	#30 10-25	#80 0-10	R	3	*	R	90-100	45-65	0-10 90-100		55-75		#3 0-10	R(2)@1 1/2"	θ
COLORADO	9-6 1/2-9	20'	100		20-70		5-20	0-5		2 1/2	Stone 5 Gravel 15			80-100		60			5		θ
CONNECTICUT	8", 9" or 10" Uniform	20'	95				5-25	0-5	R	3	4.5	R			100		40	30	5	R(2)@3/4"	
DELAWARE	8" Uniform	20'	95				28	7	R	3	4	R	2 1/2" 100		50-75		20-45		0-5		
DIST. OF COLUM.	10-8-10	20'	85-100		#16 45-80		2-30	0-5	R	2	Stone 7			90-100	35-70	0-10 90-100	60-80	25-60	0-10	R(2)@1"	θ
FLORIDA	9-7-9	20'	95-100	85-100	#16 70-95	30-70	5-35	0-5		3	Stone 6 & 9 Gravel 20	R		97-100	65-100	40-100	30-95		0-5	Yes	X
GEORGIA	9-7-9	20'	95	#16 60-90	50-70		5-30	0-5	R	3	Stone 7	R	95-100		65-85		20-40		0-8		
IDAHO	9-6-9		100		30-70	#28 15-45	#48 20	5	R	3	6		3" 100		30-60				#4 5		
ILLINOIS	9-6-9	18'-20'	#4 95-100	70-90	#16 45-75		5-10	0-5	R	2	Stone 7 Gravel 15	R		100	70-95	60-80		10-30	#4 0-5		θ
INDIANA	9-7-9	18'-20'	95	75		#28 20-50		5	R	2	Stone 6 Gravel 15	R	100			Stone 40-75	Gravel 35-80		Stone 10 Gravel 15		θ
IOWA	10-7-10	18'	95	80		15-40		5	R	2 1/2	Stone 8	R	100		95-100		40-70	3/8" 10-30	5		Yes
KANSAS	9-7-9	20'	1/2" 100	#4 85	Gradation factor 2.4 to 3.8		#28 30	#48 5	—	2	Stone 10 Grave 12	R		95		35-65		3/8" 10-30	#4 5		Yes
KENTUCKY	9-6-9	18'-20'	3/8" 100	#4 85	40-75		30	5	R	2	Stone 5 Gravel 12	R	100		30-70				5		
LOUISIANA	8-7-8	20'	#4 95				35	7	R	R	Stone 9 Gravel 20	R	Type 100	1/4" 90-100		40-80			#4 5	—	
MAINE	9-7-9	20'	100		50-80		5-30	0-5		3	Stone 6 Gravel 15		100	90		30-75			0-5		—
MARYLAND	9-6 1/2-9	20'	1/2" 100	1/4" 85-100	#16 35-80		2-30	5		3	Stone 6 Gravel 20		95-100		1 1/2" 30-65				3/8" 5		
MASSACHUSETTS	8" Uniform	20'	100		30-75		28	8	R	3	Gravel 15		100	95	1/2" 60-85	50-75		15-25	5		θ
MICHIGAN	9-7-9 & 10-8-10	20'	90-100	#10 60-90	25-65		25	0-5	R	2 1/2	Stone 6 Gravel 10		100	90-100	50-80 100	0-30 90-100		0-5 30-60	0-10	R(2)@1"	C
MINNESOTA	9-7-9	20'	95	#10 60-90	40-60		15	4	R	2	Stone 7 Gravel 10			100		40-75		25	5		Yes
MISSISSIPPI	9-6-9	20'	100	90-100			3-30	5	R	3	Gravel 15		100		97-100		40-70	20-60	5		
MISSOURI	9-7-9	20'	95		70		20	5		2	6	R	100	100		60		20	5	C-b (2) @1"	θ
MONTANA	9-6-9		100		40-65		30	5	R	3	Stone 5 Gravel 15		3" 100			25	50		5		
NEBRASKA	9-7-9	20'	90-100		35-80		5-30	0-5	R	3	Stone 7 Gravel 15	—	Platte River Sand & Gravel		95-100		40-80		0-5		Yes
NEVADA	7-5-7-5-7 & 8-6-8-6-8		100			50		5	R	3	5		100	Well graded		2 1/2" - 1/4"					
NEW HAMPSHIRE	9-6-9 & 7" Uniform	20'	485				30	5	R	3	Stone 5 Gravel 15		3" 100		40-75				15	—	C
NEW JERSEY	8", 9" or 10" Uniform	20', 30' & 40'	95-100	#10 60		45	25	#200 5		4	3-6		100		1 1/2" 45-80		45	30	5	R @ 1 1/2", 3/8" & 3/4"	
NEW MEXICO	9-6-9		1/2" 100				30	5	R	3	7		100		1" 40-75				#4 5		
NEW YORK	8-7-8	18'-20'	100	#4 90-100	#14 45-75		5-25	6	R	2	5.7	R	Well graded		*					R@1"a	θ
N. CAROLINA	8-6-8	20-30	100	85			35	7	R	3	5	—	2 1/2" 95	Special grading for mixed stone & separated stone large & small.					10	θ(2)@3/4"	C
N. DAKOTA	9-6-9		100		75		25	5	R	3	Gravel 10		Well graded 1 1/2" - 1/4"						15		
OHIO	9-7-9	20'	95	#10 70-90	35-70		5-25	5	R	3	Stone 6 Gravel 10	R		90-100	50-90	0-25 90-100		25-60	0-10	R@1"	θ
OKLAHOMA	10-7-10	20'	100		75		25	5	R	3	Stone 7 Gravel 15		100		60-95	Stone 40-75	Gravel 40-75		5		θ
OREGON	9-7-9	20'	90-100			35		5			5		3" 100	85-100		65			10	R(2)@1"	
PENNSYLVANIA	9-7-9	18'-20'	85-100		65-80		30	6	R	3	5	R	2 3/8" 100	2 1/2" 95-100	1 1/2" 30-65			3/8" 20	1/8" 8		Yes
RHODE ISLAND	8" Uniform	20'	100		70-40		25	5	R	3	Gravel 15	R Crushed St.	3" 100	2 1/2" 85-100	1 1/2" 40-75		20-50		0-10		C
S. CAROLINA	9-6 1/2-9 7 1/2-6-7 1/2	18'-20'	95	80-100			5-30	6	R	3	6	R	* See grading requirements back page								
S. DAKOTA	9-6-9		95		70		20	5		3			100	95		75			5		
TENNESSEE	8-6-8 9-7-9	18'-20'	#4 95-100	#14 60-42			#48 2-30	0-5	R	3	Stone 6 Gravel 20	R	* 3 Sizes required - See note back page								θ
TEXAS	9-6-9	20'	95-100	#10 60-90	40-80		5-25	0-5	R	2	Stone 7 Gravel 15	R	* 4 Different gradings of coarse aggregate								
UTAH	9-6-9		100		#4 60-40		#48 5-25	5	R	3	Gravel 8		2 1/2" 100	Large Size 95	40-55	Small Size 100	50-70		5	R(2)@1"	
VERMONT	7" Uniform	18'	100				28	5	R	3	5 1/2		100	90		75			5	R@1"	θ
VIRGINIA	8-6-8	20'	100		50-75		5-25	5		3	5	R	95-100		1/4" 25-60		15-25		0-10	θ(2)@1 1/2"	C
WASHINGTON	9-6 1/2-9	20'	87-100	63-88		#28 20-37	#48 6-21	0-8	R	2	Soft pcs. + 3%	R	3" 98-100	82-95	57-75	32-55	20-40	8-23	a Opening 0-5	R(2)@1 1/2"	
W. VIRGINIA	7" & 8" Uniform	18'-20'	1/2" 95-100		75		25	5		3.	6	R	95-100		75			25	5		Yes
WISCONSIN	9-6 1/2-9 & 10-8-10	20'	95-100	Based on sample in designing mix				5	R	2 1/2	9	R	Gradation included in design of mix - furnished by engineer						5	3@1 1/2"-6 3/8" 2@3/4" *	Yes
WYOMING	9-6-9		100				25	5		3	5		100			50			5		

State Highway Departments, Corrected for 1932

Courtesy of Portland Cement Association

GENERAL				CONCRETE												FORMS	
				PROPORTIONS						MIXING				CONSISTENCY			
Use of Slag	Use of Waste Products (Chats, Screenings, etc.)	Washed & Screened Aggregate required	Cement furnished by state	Compressive strength specified lb. per sq. in. @ 28 days	Strength specified Modulus of Rupture	Proportions Specified: By Volume	Proportions Specified: By Weight	Max. amount of Water per bag of Cement	Min. amount of Cement bbl. per cu. yd.	Mixing time in minutes	Central Mixing Plant	Max. time allowed for placing Concrete after mixing (Minutes)	Min. temp. allowed for placing (°F.)	Max. amount of slump (Truncated Cone method)	General provisions only	Wood Minimum thickness allowed	Steel Pounds per foot
22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
—	X	R	—	3000		—	R	5½ gal.	1.5 to 1.6	1¼	C	30	35	1½ - 2½		On curves <150° rad.	R-8-9½
		R	No	2200			R		1.5	1½		30	35		R	—	—
	X	R	—			Designed mix W/C		5¼ gal.	1.35	1	C	30	35		—	—	
		—	No			X	R*	55 lb.	1.5	5/6		Before early hardening	35	2"		θ - 3"	θ
—	—		No	3000			94#:207#:318# Spec gravity 2.60	50 lb.		1½	—	30-40	40	1" - 3"			R
X	X	R	Yes	—	500 #/□"	1:2:3½	94:190:333	Determined by Engineer		1¼	C	30	40	2"		On curves <150° rad.	R
Crushed stone only						1:2:4, 1:2:3½ for widening				1½	No concrete laid after Nov. 15		40		R	On curves <150° rad	R-10-8
	No	R	No				6.4:1175#:2000# bag	5½ gal	1.6	1¼	θ	30	40			C	R-8" base
X	X		No				*	Type "D" gra. 5.7 gal. Others 5.4	1.5	*1¼	C	30	35	2"		On curves <150° rad.	R-8-9½
X	X	R	No		650 #/□" @ 28 days		R-94#:530#	5¾ gal.	1.5	1	X	45	35			X	R-8" base
		R	—			1:5 approx.			1.67	1		30	35	1½"			R
		R	Yes	3500 @ 14 days	650 #/□" @ 14 days	Determined by engineer Measured by weight	R	Included in design furnished by engineer		1	C	30	40	2"		X	R
θ	—	R	—		550 #/□"		*		1.7	1	—	30	35	2" - 3"		X	R-9
	—		Yes				R: Table of pps. furnished	5½ gal.		1	—		35	1½"			R
	θ	θ	No	3000		Designed mix W/C	Measured by wt. based on dry vol. wt.	5¼ gal. - Stone - 1.45 5 gal. - Mixed aggre. - 1.60		1	C	30	40			C - 2"	R
C	C	—	—	3000	650 #/□"		R Based on solid vols	5¾ gal	1.5	1	—	30	40	1" - 2"		—	R
—	X	R	Yes			Type "A" gravel 1:2:3½	Measured by wt. based on dry P. vol.	5.6 gal.	1.35	1	—	30	40		R	X	R
	—	—				Based on spec grav. & Voids in stone	R	5½ gal.	1.55	1	X	30	40	1" - 3"	b	On curves <150° rad.	R
X	C	—	R				R		1.5	1	C	45	35	1" Mach, 2" Hand	R		R-15
	—	R	No			* 1:2:3½	R	5½ gal.	1.6 or 6.01 lb.	1¼	Truck mix permitted	To be agitated 60	35		R	C	R
X		R	Yes		Design for 100 #/□" @ 28 days		R		1.5	1	C	30	35	2"		X	R-10
		R	R				R Table of pps. furnished by state	5½ gal	1.6	5/6	—	—	35		R	X	12½ - R
—		R		3600	650 #/□" @ 28 days (Tentative)	1:2:3	R	5¾ gal.	1.5	1	—	30	40	1½" - 2½"	—		R-9½
C	C	R	Yes			1:2:3½	Measured by weight	*6 gal.		1	θ	30	40	2"		C-2"	R
		R	No			1:2:3	Measured by weight		1.66	1		30		1½"	R	θ - 2¾"	θ
X	X	R	No	3000	550 #/□"		R	—		1	θ	30	40		R	C	R
	—	R	—	2800		1:2:4		6 gal	1.5	1							
—	—	R	No			1:5¼ *	Fed. Aid projects	5 gal.	1.4	1¼	θ	30	35	3" - 4"		X	R
Crushed rock or Washed gravel only			No	*		*	R1:*:3½	4½ gal.*		1¾		30	32	R			R-7½ - 9½
X	C	—	No	3000		1:2:3 Approx	R	6¼ gal	1.7	1	θ	30	35		R	—	R
C	—	R	No			1:1¼:3½ Dry also 1:1½:3 Dry basis	1:1½:3½ Dry basis			1¼		45	40		R	On curves only 2"	R-Min. 3/16"
	—		Yes				R			1		30	40	R			R-8-10
		R				1:2:3½	θ		1.54	1	θ	30	32		R	θ	θ
—	X	R	No	2500 Min. to 3300 Ave.	500 #/□"	1:5½	Volume proportions measured by weight R		6.3 sacks	1¼	C	30	35	½" - 2"		X	R
	—C	—	No				1:2:3½	5½ gal	1.4	1	C	30	35	2"		On curves <150° rad.	R
			No	3300		1:2:3½ Subject to change by eng.	Wt. measure R		1.54	1	θ	30 or 45 for central mixing	35	1½"		θ - 2¾"	θ
—		R for Gravel				1:2:3¼	1:2:3½	5½ gal.	—	1¼	C	45	—		R	On curves <150° rad.	R-8-9
		—	No		—	1:2:3	Measured by wt. Based on dry vol.	5 gal.	1.6	1	—	30	38	2" - 3"	R	X	R
X	X		Yes			Wt. pps. based on spec. grav. of 2.63 for agg.	94#:175#:365#			1¼	X	30	35		R	On curves <150° rad.	R-10⅛-10¾
						1:2:3½			1.61	1	—	30	35	1"			R
	C	R	—		750 #/□"	Spec. vol. and Spec. grav.	Measured by weight *	—	1.4	1	C	15	35	½" - 3"		On curves <150° R	R-8-9½
Crushed stone or gravel only			No	3500	500 #/□"	—	R	F.A. Proj. 5.8 State Proj. 6.75	*	1	—	30	35	2"			R
		R	Yes				1.5 Approx.		1.7	1	θ		35	½" - 1"		θ - 4"	θ - 12
		R separate wash (2 sizes)	No				R*	5½ gal.	1.5	1	—	30	35	1" - 3"		X	R-9
—	—	R	Yes			1:2:4	R on Fed Aid projects only		1.4	1½	—	90	38	4" Hand 1½" Mach.		On curves <150° rad.	R
		R	No			1:1.8:3 (Dry)	R		1.67	1	—	30	35	2"	R	R-3"	
—	—	R	No				R Table of pps. furnished		1.55	1	—	30	38	2"		On curves	R
—	Screenings —	R	C	—	750 #/□" @ 28d.	X	R Determined by lab.	Incl. in design furnished by eng.	1.25	5/6	X	30	35	2"	R	C-3"	R
X			No	3500		1:2:3 Approx.		5½ gal.	1.6	1½		45	35	2"	R	On curves only	R

A Charted Summary of Concrete Road Specifications of

Courtesy of Portland Cement Association

STATE	JOINTS									FINISHING						
	Transverse exp. joints	Spacing of expansion joints Feet	Width of expansion joints Inches	Premolded joint filler	Poured joint filler	Contraction joints	Longitudinal center joint	Tie bars across Long. joints	Dowels across Trans. joints	Longitudinal float	Scraping (straightedge)	Mach. finish	Hand finish	Surface variation maximum allowed	Penalty for excess variation	Init Protec Wet burlap
COL. №	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
ALA.	R	40-60	¾	θ	θ	R	R	R	—	R	R	R	--	⅛" in 10'	Yes	R
ARIZ.	R	33	1	R			—	—		R		R		¼" in 10'		R
ARK.	R	50	¾		R		Def. Metal R	R	6-1" ϕ x 4'	R	R	R		1/16" per ft.	Yes	R
CAL:	R	60	½	R	X	¼" x 2" @ 20' Dummy	R Straight or Dummy	—	3-¾" ϕ x 2'	R	R	R	—	⅛" in 10'	Bush hammer or carborundum	R
COLO.	R	60	½	R			Dummy R			R		R		¼" in 10'	Replace	R
CONN.	R	61'-4"	½	R	—		Straight R	X	X			R	—	¼" in 10'	Remove Inequalities	R
DEL.	R	80	¾	R			R - Dummy or def. metal	R	R ¾" ϕ Spaced 2' to 2'-6"			θ	θ	1/16" per ft.	Yes	R
D. OF C.	R	40	¾	R		C	Straight ½ - 16 - 32 ⅝ - 18 - 24	R	R	R	R	θ	θ	⅛" in 10'	Immediate adjustment	R
FLA.	R-a	a	⅝	θ	θ		a	R	a	R	R	R	R	⅛" in 10'	Immediate adjustment	R
GA.	R	40 50 Gravel Stone	¾	θ	θ	a	R	R	R	R	R	R	—	⅛" in 10'	Yes	R
IDAHO	a	a	¼ - ½	R		½" x 2" Dummy	R-a	a		R		θ	θ	¼" in 12'		R
ILL.	a	a	a				R	R		R		R	—	⅛" in 10'	Yes *	R
IND.	At bridges a —	a —	a —	θ	θ		R-a	R	R			R	C	¼" in 10'	Replace	R
IOWA	a	80 - Stone 60 - Gravel 40 - Pit run	a	R			R	R Trans 11' long	R2' @ 2' c.c.	R		R	C	¼" in 10'		R
KAN.	a	a	a	θ	θ	a	R (Metal)	R	X	R		R		¼" in 10'		R
KY.							R	R		R	θ	R	C	¼" in 10'	Replace	R
LA.					R	Dummy	R-Def. Metal	R	R	R	θ	R	X	⅛" in 10'		R
ME.	R	40	½	R			R	a	R		R	R	R	¼" in 10'		R
MD.	At bridges		1	θ	θ	Dummy @ 40	R-Dummy			R	R	R	—	¼" in 10'	Grd. down or replace	R
MASS.	R	60	½	θ	θ		R	R	R		R	θ	θ	¼" in 10'	Immediate adjustment	R
MICH.	R	a or 100	1	R		a	R	R		b	—	R	C	¼" in 10'	Immediate adjustment	R
MINN.	R-a	80'-9"	1	a	a	40'-4"	R-Dummy	R	8-¾" x 30"	R		R	—	¼" in 10'	Yes	R
MISS.	R-a	60	¾	θ	θ	30' C	R Dummy or Def. met.	R	R - ⅝" ϕ x 4'-0" 10' for 20' roads	R	R	R	C	⅛" in 10'	Yes	R 24 Hrs.
MO.	R	40'-4"	1	θ	θ		R	R		θ	R	R	C	¼" in 10'	Yes	R
MONT.	R	30	⅜	R			½" x 2" Dummy			R		θ	θ	¼" in 10'	Yes	R
NEB.	a	100	1	R	b	½" Dummy @ 25'-33'-4"	R	R	R	R	θ	R	C —	5/16" in 10'		R
NEV.	R	100	1	R		½" Dummy @ 25'	½" Dummy			R				¼" in 10'		
N.H.	R	50	½ - ¾	θ	θ		Straight, no metal	R	R 2' x ⅝" ϕ 10 for 20' roads			R	C	¼" in 10'	Yes	R
N.J.	R-a	45'-4"	½	θ	θ		R - Straight		12 - ¾" x 20" for 10' strip			R	—	⅛" in 10'	Immediate adjustment	R
N.M.	R	60	¾	R			R	R	R	R		R	C	¼" in 10'	Yes	R
N.Y.	R	78½	a	θ	θ		R-Straight		5 - ½" x 18' for 10' strip	R		R	—	¼" in 10'	Immediate adjustment	R
N.C.							R When gravel aggrs. used	R	⅝" ϕ x 4'-0" @ 2'-0" c.c.	R	θ	R	—	⅛" in 10"	Yes	R
N.D.	R	120	1	R		40'	R	R	R			θ	θ	¼" in 10'		R
OHIO	a - May 15 - Sept. 15 R - Sept. 15 - May 15		a	θ	θ	40' ±	R	R	4 edge bars R @ all joints		R	R		3/16" in 10'	Grd. down or replace	R
OKLA.	R	a	a	θ	θ		R - Plate or Dummy	R		R	R	R	—	3/16" in 10'	Immediate adjustment	R
ORE.	R	90	¾	R		R15'	R - Dummy or Contact	R	R	R	R	R	—	⅛" in 10'		R
PENN.	R	a	½	R			Dummy or Def. metal	R-a		θ	R	θ	θ	⅛" in 10'	Immediate adjustment	R
R.I.	R	a	¾	R	b		a		R			—	—	¼" in 10'		R
S.C.	R	40	½ - ¾	θ	θ		b	R		R	θ or long hdle float	R	C	⅛" in 10'	Yes	R
S.D.	R	40	⅜	R			R	R				θ		¼" in 10'		R
TENN.	b	a	a	a	a	a	R Def. Metal	R-a	1" x ½" x 2' @ 5' c.c.	R	R	R	C	¼" in 10'	Yes 1 sq. yd. for each	R
TEX.	R	78.5 - 116.5 - 192.5	1" - 3"	—	a	R	R	R	a	R	R	R	—	1/16" per ft.		R
UTAH.	R	60	¾	R	θ	Dummy ¼" x 2"	Dummy ¼" x 2"			R		R	θ	¼" in 10'		R
VT.	R	55-65	½	R			a	R	R		R	R		¼" in 10'		R
VA.	—	a	½ - 1	R							R	θ	θ	⅛" in 16'		R
WASH.	R	60	¾	R		R-Dummy ½" x 2" @ 15'	R-Dummy ¼" x 2" or 2½"	R	14 - ¾" ϕ 2'	R	R	θ	θ	⅛" in 10'	Replace	R 24 Hrs.
W. VA.	R	93	¾	R		46.5	R	a		R	R	θ	θ	1/32" per ft.	Immediate adjustment	R
WIS.	R	90'-6"	1	θ	θ	R	R-Dummy or Def. plate	R	R-4' @ 2' c.c.	R	R	R	C	⅛" in 10'	Yes - Min. 1 sq. yd.	R
WYO.	R	60	½	R			R					R		1/16" per ft.		

State Highway Departments, Corrected for 1932

Courtesy of Portland Cement Association

	CURING									SUBGRADE PREPARATION					REINFORCEMENT			
ial tion	Wet earth Hay or Straw	Ponding method	Other methods	Calcium chloride: Surface application	Calcium chloride: Admix. integral with mix water	Days kept wet	Days kept covered	Days kept closed	Strength at which pavement may be opened to traffic	Sprinkling	Tar paper	Sub grade template	Test cores to check strength or thickness	Penalty for deficient strength or thickness	Longitudinal shear bars	Mesh lb. per 100 sq. ft.	Bar mats lb. per 100 sq. ft.	Other bars Corner reinf. Circum. reinf. etc.
Paper or other methods																		
56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74
	θ	θ		X	X	7	18	21	3000 #/□" Compr. 500 #/□" Mod. Rup.	R		R	Yes	Yes	R	R-a		
	R	Prefer				12	15	15				R	b					
	θ	θ	Silicate of Soda	θ		10±	10±	20±	3000 #/□" Compr. 500 #/□" Mod. Rup.	R		R	Yes	Yes thickness	R	—		—
C	—	—	Spray θ Imperv. ctg. C	X	C—	8	8	14	Mod. Rupture 600 #/□"	R		R	Yes but not specif.		R	—	—	R
	R	θ				10		21		R		R				—		—
			36 Hrs. Wet burlap		R	36 hrs.		Beam test	Mod. Rupture >300 #/□"	R		R	Yes thickness			R-a	R-a	
	C	C	Silicate of Soda	C	—	6	10	14		R		R	Yes thickness	Yes thickness				
			72 Hrs. Wet burlap	θ	—			Beam test	Mod. Rupture >400 #/□"	R		R	Yes thickness			50		
	Wet earth θ	θ				10	10	21				R	Yes	Yes thickness		44	b	a
	θ	—	72 Hrs. Wet burlap	X	X	10	10	—	Mod. Rupture 500 #/□"	R		R	R	Yes		Spec. cases only (a)	(a)	
	—	R				10	10	30										
	θ	θ		θ		10	10	14—	By test			R	Yes thickness	Yes thickness	Edge # X ¾"-θ		—	b
	Straw	θ		C		10	10		Beam test 550 #/□"	R		R	Yes thickness	Yes thickness	a		a	
	θ	θ	Imperv. ctg. Paper θ Burlap 72 Hrs.	X	θ after Oct. 15	7	7	7	Mod. Rupture 500 #/□"		R	R	Yes-Strength & thickness		R			Corner & Circum. R.
	θ	θ		X	C	Until transverse str. reaches 500 #/□"			Transv. strength 300 #/□"	R	R	R	Special cases only		R	a	a	a
	θ	θ		X	X	8	14	14	Mod. Rupture 650 #/□"	R		R	Yes thickness	Yes thickness	a	C	—	
	θ	θ	Silicate of Soda	X	θ	10	10	14	Mod. Rupture 650 #/□"	R	Special cases	R	R	Yes		a	b	
	θ	C			—	10	12	+9		R		R				—	a	
			Silicate of Soda					14		R		R	Yes	Yes thickness	—			—
	R	θ		C	—	With $CaCl_2$ ½	10	+7	Mod. Rupture 500 #/□"	R		R	Yes	No	R	—	a usually	Right angle R
—	R	θ		X	X	7			Mod. Rupture 550 #/□"	R	—	R	Yes thickness			θ	θ	
C	Methods specified by special provisions					3		10-21	Mod. Rupture 450-500 #/□"	R		R						Corner & Circum. R.
	θ Earth	θ		X	X	10	10	10-14	Mod. Rupture 650 #/□"	R		R	Yes-Strength & thickness	Yes thickness		θ		
C	θ	θ		θ	—	7	7 Earth Water	Beam test	Mod. Rupture 300 #/□"	R	C	R	Yes-Check qual. & thickness	Yes thickness	R	a	θ	a
	θ	θ				10	10	28										
C	θ	72 Hrs.	72 Hrs. Wet burlap θ	X	C	7	7	Beam test	Mod. Rupture 500 #/□"		R	R	R	Yes thickness		b	b	a
		R				12		21	Compression 2800 #/□"			R	Yes					
Yes Paper	R	θ	Paper	θ	θ	7	7	7	Beam test	R		R	Yes	Yes thickness	R	a		a
	θ		Bituminous		C	10	10	12		R		R	Yes-Strength & thickness	Yes thickness		R-a	R-a	Corner R
		R				10	18	30				R				a		a
	Hay θ*	θ	Bituminous		a	10	15*	15*				R	Yes	Yes thickness		R-a	R-a	Double Mat a
	θ	θ	72 Hrs. Wet burlap θ		C	10	14	14	Mod. Rupture 450 #/□"	R		R	R	Yes thickness	R		—	b
	θ	θ				10	18	21				R				a		a
			C	C		7	7	By test	Mod. Rupture 500 #/□"	R			R	Yes		56		
	R Earth				C	10	14	14	Mod. Rupture 300 #/□"	R		R	—	Yes thickness	a	a	a	a
	θ	θ				10	14	21		R		R						b
Earth-X Hay-Straw θ				X	θ	θ 24 Hrs.	18 $CaCl_2$	Beam test	Modulus of Rupture	R		R	R	Yes thickness	Yes	48 a	a	Interior corners
Yes	θ	C	Paper	θ	—	10	12	15	Beam test	R		R				42 a		Ubars
	θ	θ			C	8	18	18		R		R	Yes	Yes thickness		b Special cases only		
	θ	θ				14	14	21										
	R	C	72 Hrs. Wet burlap			10	18	21	Mod. Rupture 600 #/□"	R		R	R	Yes	b		b	a
	θ	θ		C	X	10	10	10	Mod. Rupture 500 #/□"	2" Saturated		R	Yes			a	a	
		R				15		20				R				—		—
	θ					θ With $CaCl_2$ — 2 hrs without — 2000 #/□" — 2 Compr.			7000 #/□" Compr. 380 #/□" Mod. Rup.	R		R			R	—	a	Corner R
	R	θ		θ	θ	14	18	21	Compression 2500 #/□"	R		R	Yes	Yes thickness				
	θ	θ *	Sprinkling Imperv. ctg.	X	—	10	14	14		R		R		Yes (Non Shrinkage)	R		b	b
	R		Sodium Silicate on	θ		10	18	21	Compression 3000 #/□"	R		R	Yes	Yes		43 a		
	θ	θ	X	θ	X	+7	+7	+7	600 #/□" but +7 days	R		R	Yes but not specif.	No		C 58		
	R	θ		C	C	10	14	14				R						

EXPLANATION OF SYMBOLS USED IN CHARTED SUMMARY

SYMBOL	INTERPRETATION
R	.....Definitely required.
—	.....Provided for in specifications under certain conditions or with certain requirements.
X	.....Specifically prohibited.
C	.....When special permission is necessary or only if provided for in "Special Provisions."
θ	.....Optional with contractor.

SYMBOL	INTERPRETATION
a	.....As shown on plans.
b	.....When or where required.
>	.....Greater than.
≯	.....Not greater than.
<	.....Less than.
≮	.....Not less than.
*	.....Refer to "NOTES" under the name of the state listed below.

NOTES

CALIFORNIA: *Column No. 1*

Dimensions of slab and crown are given in decimals of a foot as 0.75'-0.6'-0.75' but spacing of bars is designated in inches.

Column No. 11

The loss in dry shot rattler test shall not exceed 25%.
The loss in wet shot rattler test shall not exceed 55%.
The loss in Los Angeles rattler test shall not exceed 37% after 500 revolutions.
The loss in Los Angeles rattler test shall not exceed 8% after 100 revolutions.

Column No. 29

"The proportion of fine aggregate to coarse aggregate shall depend upon the grading of the two materials but the amount of fine aggregate shall always be minimum amount required, which combined with cement, shall produce only sufficient mortar to completely fill the voids in the coarse aggregate and leave a slight excess for finishing."

FLORIDA: *Column No. 29*

Type A—Gravel 94:538. Type C—Imported Stone 94:538.
Type B—Local Stone 94:526. Type D—Gravel 94:532.

ILLINOIS: *Column No. 54*

Bush hammer not permitted for removing surface irregularities—must use carborundum brick and water. For ¼" to ½" variation—penalty 1 Sq. Yd. Over ½" variation—Replace.

INDIANA: *Column No. 29*

The fine aggregate shall in no case be less than thirty-five (35) nor more than forty (40) per cent of the total weight of aggregate used, but the aggregates shall be proportioned to use the maximum amount of coarse aggregate and the minimum amount of fine aggregate which will produce a workable mix. No correction will be made for moisture content—work from 1.7 cement content.

IOWA: *Column No. 59*

Paper 6 days—Wet earth 6 days.
Bituminous coating with whitewash cover.
Wet burlap 72 hours.

NEW HAMPSHIRE: *Column No. 28*

Minimum ratio of cement to total of separate volumes of fine and coarse aggregates 1:5¼.

NEW JERSEY: *Column No. 26*

75 to 90 per cent of strength of initial test cores.

Columns No. 28 and 29

Specifications provide proportions of one cement, 3½ coarse aggregate by volume, fine aggregate to be equal to the void content of the coarse aggregate divided by 0.9. All proportions on dry basis and measurements by weight,

Column No. 30

Specifications provide the use of not over 4½ gallons of water exclusive of that in the aggregates, which gives a total water content of approximately 5 to 5½ gallons per sack of cement.

NEW YORK: *Column No. 15*

Grading—square openings for sieves:
Size No. 3-A passing 1¾" retained on 1", 50 to 60%.
Size No. 2 passing 1" retained on ⅝"
Size No. 1 passing ⅝" retained on ¼" } 40 to 50%. *
*At least 40% of combined No. 1 and No. 2 shall be No. 1.

Column No. 29

All coarse aggregate to be stocked and weighed in 2 sizes, except where volume batching is allowed on small jobs.

Column No. 57

Hay or buckwheat straw. During cold weather hay only without burlap may be used for cover.

Columns No. 63-64

During the period June 1 to September 15 keep cover wet for 10 days; may remove cover and open pavement at end of 10 days. During balance of year keep wet 10 days, remove cover and open payment in 15 days.

Column No. 74

Double mat 5 ft. long used at slab ends.

SOUTH CAROLINA: *Column No. 13*

Coarse aggregate:
Passing 2½" not less than 95%.
Passing 2½" retained on 1½", 15-35%.
Passing 1½" retained on ¾", 25-60%.
Passing ¾" retained on ¼", 18-35%.
Passing ¼" not more than 10%.
Passing No. 16 sieve not more than 1.5%.

TENNESSEE: *Column No. 13*

Coarse aggregate.
Percentage retained on square lab. screens

	Size No. 1	Size No. 2	Size No. 3
2½"	0	0	0
2"	0-5	0	0
1½"	15-30	0-15	0-5
1"	40-65	20-50	5-20
¾"	60-80	50-75	25-50
⅜"	80-95	80-95	75-95
No. 4	95-100	95-100	95-100
No. 8	100	100	100

Column No. 29

The proportions shall be as follows:
Water, not more than .....5.6 gallons
Cement .....94 lbs.
Combined fine and coarse aggregate.....583 lbs. using gravel coarse aggregate, or .....566 lbs. using crushed stone coarse aggregate.

TEXAS: *Column No. 13*

Coarse aggregate—4 sizes:

Percentage retained on:	Size No. 1	Size No. 2	Size No. 3	Size No. 4
3" screen	0	0	0	0
2½" screen	0-5			
2" screen		0-10		
1½" screen		10-35	0-10	
1¼" screen	25-50			
1" screen			15-30	0-15
¾" screen	40-75	40-70	35-70	15-30
½" screen				40-70
¼" screen	90-100	90-100	90-100	90-100
10 mesh sieve	99-100	99-100	99-100	99-100

Column No. 31

Proportions are based on *absolute volumes* requiring a minimum of 1.25 barrels cement for Federal aid projects and 1.0 barrels cement for State projects.

VERMONT: *Column No. 29*

Proportions by weight are 94 lbs. cement to 180-200 lbs. of fine aggregate, and sufficient coarse aggregate to maintain cement content at not less than 1.5 bbl. per cu. yd.

WASHINGTON: *Column No. 58*

Ponding or sprinkling method may be used subject to approval of Engineer. Prohibited in Eastern Washington after September 1.

WISCONSIN: *Column No. 20*

Aggregates subjected to laboratory test.
3 sizes when 2½" max. is used (2½-1½), (1½-¾), (¾-¼).
2 sizes when 1½" max. is used (1½-¾), (¾-¼).

Specification for Cement Bound Macadam Pavement

This Specification Is Published by the Portland Cement Association, 33 West Grand Ave., Chicago.

General

Description.—Cement bound macadam pavement is rolled coarse aggregate held together by portland cement grout. It is to be constructed by placing grout having the consistency of thick cream over a layer of rolled aggregate of the specified thickness in such a way that the grout penetrates the voids in the aggregate and completely fills them. The grouted coarse aggregate is then consolidated by rolling. Excess grout is removed by brooming or squeegeeing transversely.

Materials

Portland Cement.—Portland cement shall be of American manufacture conforming to the Specifications for Portland Cement (Serial Designation C9-30) of the American Society for Testing Materials and subsequent revisions thereof. Cement shall be protected from damage by moisture and if so damaged shall not be used.

Fine Aggregate.—Fine aggregate shall be a clean, durable, strong, natural sand at least 95 per cent of which shall pass a standard number 8 sieve, not less than 10 nor more than 30 per cent shall pass the standard number 50 sieve, and not more than 5 per cent shall pass the standard number 100 sieve.

Fine aggregate showing more than 6 per cent, by volume, of clay, loam, or silt in 1 hour's settlement, after being shaken in an excess of water, shall not be used.

Fine aggregate which fails to pass the Standard Colorimetric Test of the American Society for Testing Materials (Serial Designation C40-27) shall not be used unless it can be shown that the failure to pass is caused by harmless materials.

Coarse Aggregate[1],—Coarse aggregate shall be crushed stone or a crushed gravel containing not more than 20 per cent of uncrushed particles. Not more than 5 per cent shall pass a standard 1-in. sieve, not more than 15 per cent shall pass a standard 1½-in. sieve, and not more than 10 per cent shall be retained on a standard 2½-in. sieve.

Crushed stone shall not show more than 4 per cent loss in the Standard Test for Abrasion of Rock (Serial Designation D2-26) of the American Society for Testing Materials and shall have a toughness of not less than 6 when tested in accordance with the American Society for Testing Materials Standard Method of Test for Toughness of Rock (Serial Designation D3-18). Stone showing a loss of more than 4 per cent but not more than 6 per cent in the Standard Test for Abrasion of Rock may be used provided not more than 5 per cent passes a 2-in. sieve, not more than 15 per cent passes a 2½-in. sieve, and at least 90 per cent passes a 3½-in. sieve.

Crushed gravel shall not show more than 15 per cent loss by abrasion. The Tentative Standard Test for Abrasion of Gravel (Serial Designation D289-28T) of the American Society for Testing Materials shall be used except that the particles shall be graded between 1½ and 2½ in.

Water.—Water shall be clean and free from oil, acid, alkali, or vegetable matter.

Joint Filler[2].—Expansion joints shall be of the poured type, or a board left permanently in the pavement.

Boards for joints shall be one inch thick and have a width ½ in. less than the depth of the pavement.[3]

Construction

Subgrade.—The subgrade shall have the grades shown on the plans. The surface of the subgrade shall not have inequalities exceeding ¾ in. when measured from a 16-ft. straightedge.

The subgrade shall be compacted with a roller weighing not less than 5 tons.

Shoulders of the width shown on the plans shall be in place before the pavement is opened to traffic. If berms outside the forms prevent drainage from the subgrade during construction, trenches shall be dug through them, prior to grouting, at intervals not exceeding 50 ft., to assure drainage of excess water away from the slab.

Forms.—Side forms shall be used. They shall have a height equal to the depth of the pavement and be strong enough to withstand the weight and pressure of rolling. Seel or 4 by 6-in. wood forms may be used. Forms shall be firmly staked in place and shall not be removed until after the pavement has hardened.

Joints.—A longitudinal dummy joint shall be provided for by setting a 1 by 2½-in. wooden strip on the subgrade, along the center line. The strip shall be set in a straight or evenly curved line with its 2½-in. edge vertical, and be firmly fastened in place so that it will not be disturbed by subsequent construction operations.

Expansion joints[2] — inch wide shall be put in at —-foot intervals. Expansion joints shall extend from top to bottom and edge to edge of slab and be free from obstructions of any kind.

Board expansion joints shall be installed by trenching the coarse aggregate before it is grouted, setting the board on the subgrade, perpendicular to the subgrade, firmly staking it in this position, and replacing and compacting the coarse aggregate about it. Stakes holding the board in place shall be sufficient in number to prevent any movement of the board during the rolling and grouting operation.

Poured joints shall be installed by trenching the rolled aggregate and setting a bulkhead[4] in place on the subgrade, at right angles to the subgrade, replacing and compacting the aggregate about it. After the slab has partly hardened the bulkhead shall be removed. Before the pavement is opened to traffic the expansion joint space shall be filled with poured joint filler.

A construction joint shall be installed wherever grouting operations are suspended for sufficient time to permit hardening of the grout. Where the construction joint comes within 10 ft. of the location for a transverse expansion joint, the expansion joint shall be placed at the construction joint. The construction joint shall be formed by staking in place at right angles to the center

[1]If uncrushed gravel is used as coarse aggregate, the same specification is suggested as for crushed gravel, including 15 per cent of abrasion. Construction methods will probably have to be changed, however, to eliminate hauling over or rolling of the ungrouted gravel.

If crushed blast furnace slag is to be used, the following specification is suggested:

"Crushed blast furnace slag weighing 75 or more pounds per cubic foot shall be of such size that not less than 90 per cent will pass a standard 2½-in. sieve, not more than 15 per cent will pass a standard 1½-in. sieve, and not more than 5 per cent will pass a 1-in. sieve.

"Slag weighing less than 70 pounds per cubic foot shall not be used.

[2]Omit if expansion joints are not used. When expansion joints are used, 1-in. joints at 150 to 200-ft. intervals are recommended.

[3]Where creosoted material is available, its use is desirable.

[4]It may be necessary to armor the bulkhead to prevent embedding of stone under rolling.

line and subgrade a bulkhead of wood or metal cut to the cross-section of the pavement and stiff enough to remain straight and upright under the weight and thrust of the roller. Coarse aggregate shall then be compacted about the bulkhead and grouting shall not proceed beyond it. Any aggregate covered with or containing grout ahead of bulkhead, in the direction of grouting, shall be removed and replaced with clean aggregate, and the bulkhead shall be removed before grouting operations are resumed.

Placing and Rolling Coarse Aggregate.—After the subgrade has been properly prepared the coarse aggregate shall be spread between the forms by an approved method to a depth which, after rolling, will provide a thickness for penetration equal to that required for the finished pavement. The coarse aggregate shall be so handled that there will be no segregation of sizes nor any other variation in distribution and a uniform, even surface having a slope from center to sides of ¼ in. per foot is obtained. If any coarse aggregate becomes dirty or mixed with the subgrade or shoulder material it shall be removed and replaced with clean aggregate before grout is placed. Unless approved by the engineer, due to special conditions, only sufficient coarse aggregate for one day's grouting shall be in place at one time.

The loose, ungrouted aggregate shall be rolled with a tandem roller weighing not less than 5 nor more than 7 tons. Rolling shall be only sufficient to smooth the surface and no area shall be rolled more than twice. After rolling, the surface shall be tested with a straightedge and inequalities corrected.

Grout.—The grout used in filling the voids in the coarse aggregate shall be proportioned 1 bag (94 pounds) of cement to 1.7 cubic feet of sand, measured dry and rodded (approximately 2 cubic feet in the damp, loose, field condition) and sufficient water to produce a grout having the consistency of thick cream.

Mixing Grout.—Cement grout may be mixed at a central plant, truck mixed, or mixed on the job, providing the equipment meets with the engineer's approval. Suitable agitator bodies will be required for central mixing plant grout.

Job Mixed Grout.—Where the grout mixer operates over the rolled aggregate, provisions shall be made so that the aggregate is not displaced or crushed by the mixer wheels and so that voids in the coarse aggregate are not clogged by grout materials spilled from the charging device.

Mixing Time.—The mixing period for grout will depend upon the type and size of mixing equipment used. At least one minute of mixing will be required for job mixing.

Where a central mixing plant is used, at least one minute of mixing will be required and the grout shall be transported in agitator bodies which will agitate the grout sufficiently to prevent segregation en route.

Where a central proportioning plant and transit mixer bodies are used, the drums of the body shall be rotated while in transit to the job and during discharge operations in order that there may be proper mixing and no segregation of grout ingredients. If, during discharge, the grout does not appear to be properly mixed, the drum shall be closed and rotated at the proper speed until thorough mixing is obtained.

Consistency.—The consistency of the grout shall be such that no separation of ingredients will occur and that voids in the rolled coarse aggregate will be completely filled. An excessive amount of free water coming to the surface will be evidence that too much mixing water is being used.

Mixing Water.—A positive approved method shall be provided for measuring and loading mixing water. The water content required (including moisture in the sand) will vary with temperature conditions, size and kind of coarse aggregate, and subgrade on which the road is constructed, but will amount to approximately (depending upon these conditions) 6½ to 7½ gallons per sack of cement. Proper water content will be determined by the engineer.

Distributing Grout.—Regardless of mixing method, the grout shall be deposited upon the coarse aggregate without segregation and in such a way that the coarse aggregate is not disturbed. Grouting operations should be continuous between joints or during each days' operation. The use of two or more light push brooms for assisting grout distribution will be required.

Initial Grout Rolling.—As soon as a sufficient amount of grout has been deposited (50 to 100 sq. yds.), the grouted slab shall be immediately rolled with a tandem roller weighing not less than 5 nor more than 7 tons in order to facilitate complete penetration of the grout. (One rolling should be sufficient at this time.)

Straightedging Surface.—The grouted surface shall be straightedged immediately after the initial rolling and all irregularities greater than ½ in. on a 16-ft. straightedge shall be adjusted by proper use of stone forks while the grouted slab is still pliable (due to wet grout). If depressions should occur which cannot be adjusted in this manner, then ½-in. aggregate shall be added and thoroughly consolidated to give an even surface. If the straightedging and leveling work is done at the proper time, very little small stone will be required to adjust the surface.

Final Grout Rolling.—At the proper time, determined by temperature and working conditions, the final rolling (with a 5 to 7-ton tandem roller) shall begin. Rolling shall continue and, if necessary, additional grout shall be added until an even, dense surface is obtained, but with a minimum accumulation of grout above the surface of the coarse aggregate. The desired amount of surplus grout is to be determined by trial and must be sufficient to provide for further settling into voids, to insure against projection of coarse aggregate above the surface, and to allow an even surface finish.

Finishing Surface.—After the final rolling is completed, any excess grout shall be evenly distributed over the surface. After an interval during which excess moisture is allowed to come to the surface, but before initial hardening begins, all excess grout shall be swept or squeegeed from the surface transversely, leaving only a very thin film of grout over the coarse aggregate. This shall be carefully done, so as not to disturb the coarse aggregate.

Curing.—When water is available along the roadway in city mains or other pressure lines, the pavement shall be cured with wet burlap. The burlap shall be placed on the pavement as soon as it can be done without marring the surface. It shall be wet when put on and be left in place and kept wet for 48 hours.

When the water is not available in pressure lines, the contractor may supply his own pressure lines, or he may, if he prefers, omit curing and accelerate hardening by adding to the grout 2 pounds of calcium chloride for each sack of cement.

The calcium chloride shall be introduced into the mixer drum in solution, and either with or following the mixing water.

Opening to Traffic.—Pavement may be opened to traffic in five days in the period from June first to October first or when similar favorable weather conditions prevail. At other periods, the pavement shall be opened to traffic as directed by the engineer.

Slag as an Aggregate for Concrete

Experiences of the Ohio State Highway Department in the use of slag as aggregate for concrete were outlined by R. R. Litehiser, Chief Engineer, Bureau of Tests, of the department in a paper presented at the 1934 Conference on Highway Engineering at the University of Michigan. The matter following is quoted from his paper:

Our specifications require that the slag shall be composed of air-cooled blast furnace slag and shall be clean, sound, durable, reasonably uniform in density, and free from thin, elongated or glassy pieces. Slag is required to meet the same quality requirements as determined by our modified abrasion test and soundness test, as crushed limestone. In this respect there is an equation with gravel also, taking into consideration the amount of roundness and angularity, so that we virtually have a specification of coarse aggregate for concrete which may be met by gravel, limestone or slag of the same physical

Table I.—Compressive Strength of Concrete Cores Equated at 28 Days, Pavement Concrete 1:5½ Mix

Year	Coarse Aggregate	Number of Tests: Plaster of Paris Caps	Number of Tests: Leadite Caps	Compressive Strength in Lbs. Per Sq. In.: Plaster of Paris Caps	Compressive Strength in Lbs. Per Sq. In.: Leadite Caps
1932	Gravel	1,326	...	3,100	.....
	Limestone ...	740	...	3,040	.....
	Slag	756	...	3,220	.....
1933	Gravel	564	701	3,229	4,704
	Limestone ...	249	285	3,105	3,900
	Slag	181	56	3,080	4,742

characteristics. In addition, slag is required to meet a minimum weight requirement of 70 lb. per cubic foot, compacted, as lighter slags have not been generally satisfactory as concrete aggregate.

Our specifications for concrete make no distinction as to kind of coarse aggregate. Both fine and coarse aggregate are proportioned by weight of dry, loose material. Coarse aggregate shall be thoroughly wet before being batched, if in the opinion of the engineer it is necessary to obtain concrete of uniform consistency. This is almost universally necessary with slag, as the absorption of slag varies over a much wider range than either limestone or gravel.

Further, when slag is used, the batching equipment shall be so constructed and adjusted that the volume of the coarse aggregate shall not exceed the volume designated in the job mix as some variation in the unit weight of slag may be expected even from the same source.

Natural sand and limestone sand are permitted under our specification as fine aggregate for portland cement concrete. We have no specification for slag sand for portland cement concrete. So far as I know slag producers have not yet entered this field. The slag sand included in this summary is a comparatively fine sand which is required in certain grades of bituminous concrete.

There is more variation between the average weights of slag than for limestone and gravel. One must be alert to this fact in using slag as a concrete aggregate.

The compressive strength, equated at 28 days, of concrete cores cut from our concrete pavement during 1932 and 1933 is shown in Table I. It happened during 1933 we adopted the practice of capping our cores with Leadite so that for that year we have results with two methods of capping. While not related to a talk on slag, the increase in strength which accompanied the use of Leadite caps may interest laboratory men.

Precautions for Concrete Pavement Construction in Cold Weather

A pamphlet published by the Portland Cement Association, 33 West Grand Ave., Chicago, Illinois.

Delays beyond the contractor's control or unusually early cold snaps sometimes leave a short stretch of concrete pavement incomplete when freezing weather sets in. If completion is postponed until spring, the public may be greatly inconvenienced, and the contractor suffers loss from capital and equipment tied up as well as delay in starting the next season's contracts.

Under these conditions, if only a small yardage is involved, it may be to the interest of both the contractor and the public to provide means for properly completing the contract at once.

Construction of concrete pavement during extremely cold weather, or upon frozen subgrade, is *not* recommended, but observance of the following principles will enable construction to be carried on in lower temperatures than would otherwise be safe.

Principles of Cold Weather Paving.—Low temperatures retard, and warmth accelerates the hardening of concrete. To insure successful concrete paving work in cold weather, the mass of concrete as placed on the subgrade should have a temperature of not less than 80 degrees Fahrenheit. The pavement must be covered at the earliest possible moment with canvas shelters, hay or straw to retain its heat until the concrete has attained the desired strength, as shown by test specimens.

The use of high early strength concrete will usually be found economical in greatly reducing the time during which high temperature must be retained in the concrete and guarding against the danger of a sudden, severe drop in temperature.

Heating Aggregates and Mixing Water.—Where aggregates are stored in stock piles, it is possible to heat the piles of sand and stone by introducing jets of live steam below the surface of the pile or by pipe heaters. The latter may be of two kinds. Sections of pipe similar to a boiler smoke stack are placed along the ground and fires built inside of them. The aggregates are piled over and around the pipe. If the job warrants it and a steam boiler is accessible, coils may be constructed of pipe into which high pressure steam is turned. These coils may be placed horizontally or vertically in the stock piles.

The use of center steam pipes or jets of live steam are preferable to the use of a fire. The heat is more constant and more uniformly distributed through the piles and there is no danger of injuring such aggregate as flint or quartz gravel by too high temperatures.

If the material is supplied from a central proportioning or mixing plant, rotary heaters may be installed similar to those used for bituminous mixes. If it is necessary to haul batches some distance to the mixer it may be necessary to apply more heat at the mixer.

The most convenient method for heating mixing water is to use a small portable furnace or brazier containing coils of pipe and burning coal, wood or coke. These coils are connected in the water line to the mixer at any convenient point.

Some special heaters are now on the market which may be used if the weather is not too cold. These consist of small portable oil heaters which will turn a long, intensely hot flame directly into the mixer drum and heat the concrete while mixing is going on.

Protection of Paving During the Curing Period.—After the concrete has been laid it is of vital importance that its temperature be maintained at or above 60 degrees Fahrenheit for at least 10 days in order that the concrete may attain the required strength.

Immediate protection must be given after finishing so that the heat introduced by heating the aggregate and mixing water will be retained as long as possible.

By the use of properly designed, high early strength concrete, the time of curing may be cut down to 3 days, or even less, if the necessary heat is retained.

If the concrete is placed on a fairly warm day the surface may have hardened sufficiently by night to allow a couple of feet of hay or straw to be placed on the surface. If snow or severe cold may be expected, it is desirable to spread canvas over the top of the hay or straw covering. Canvas covers on light frames to maintain an air space above the surface of the pavement may also be used. Earth banked on the edges of the canvas will help to hold it in position and keep out much cold air. The canvas covering may be kept from one to two feet above the surface of the pavement in order to make room for the introduction of lanterns, steam coils or salamanders. If it is necessary to use these, care should be taken that the surface of the pavement does not dry out too rapidly.

High Early Strength Concrete.—The use of high early strength concrete will greatly reduce the time during which the pavement must be protected. The factors to secure this high early strength concrete are:

1. A slight increase in quantity of cement.
2. The use of a minimum quantity of mixing water.
3. Full time of mixing.

The temperature of the concrete should be maintained at or above 60 degrees to develop this high early strength promptly. By limiting the amount of mixing water to 5 gallons per sack of cement, a 1:1½:3 mix properly cured should attain a strength of 1500 pounds per square inch in 3 days and 2400 pounds per square inch in 7 days. Reducing the mixing water to 4 gallons per sack of cement will give a strength of 2100 pounds at 3 days and 3100 pounds at 7 days for a 1:1:2 mix. An allowance must be made for all free water or moisture carried in the aggregates in determining the number of gallons per sack of cement for the mix.

Increasing the mixing time from one to two minutes will add about 100 pounds per square inch to the strength of all mixes at 3 days and 5 minutes mixing time will add about 200 pounds per square inch.

Detailed recommendations for any particular case will be promptly furnished by the nearest district office or representative of the Portland Cement Association. Since it is difficult in cold weather to know that the concrete is maintained at a temperature of not less than 60 degrees during the curing period, it is recommended that cylinders be cast by the side of the work and cured under exactly the same conditions. These should be capped and broken in a standard testing machine at 3, 7, 14 days or whenever it is desired to determine the strength of the pavement.

When tests show that the pavement has reached the desired strength, it may be opened to traffic with confidence that it will be thoroughly satisfactory.

Use of Calcium Chloride and Similar Compounds in Cold Weather Construction.—Within certain limitations* calcium chloride or calcium oxychloride may be used in portland cement mixtures to hasten hardening and to increase early strengths. The amount of the admixture required to produce the most beneficial effect seems to be dependent upon the chlorine content. Only small amounts of these admixtures may be used to advantage. The greatest acceleration is obtained with 2 to 4 per cent of calcium chloride or 7 to 10 per cent of calcium oxychloride by weight of the cement. With these percentages, tests covering a period of 3 years show no indications of reduced strength. If quantities of these materials greater than the above amounts are employed, the strength decreases.

When these compounds are used in cold weather work, they should not be used as a substitute for heating the materials and furnishing proper protection and heat to the finished structure, but only as an added precaution and as a means of shortening the curing period.

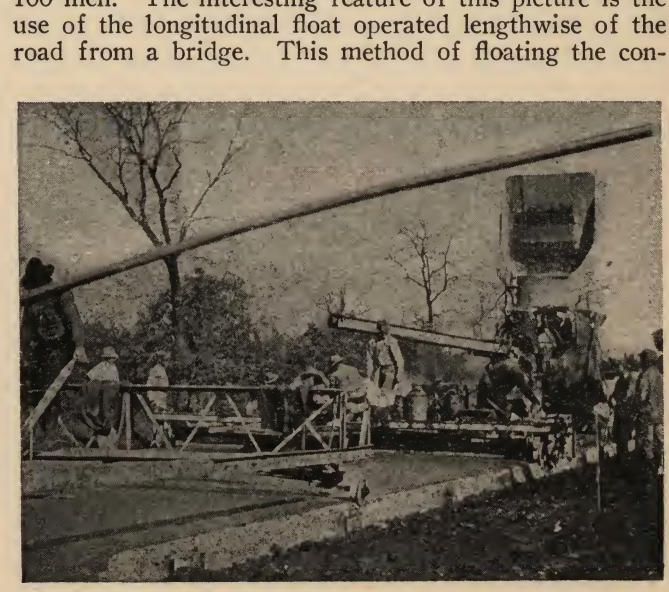
It must be remembered that no matter what method is used to accelerate hardening and obtain high early strength, the hardening will not take place with the rapidity desired unless the temperature is maintained at or above 60 degrees. It must also be remembered that the surface of the pavement must remain sufficiently moist during the period of curing to prevent checking and insure a tough, dense surface. If any lack of moisture is noticed, the surface should be sprinkled at intervals during the curing period.

*There is evidence to show that calcium chloride and similar compounds do not react in the same manner with all brands of portland cement. Trial batches of the brand of cement and the brand of accelerator proposed to be used should be made up and rate of hardening at the specified temperature noted before proceeding with their use in important work.

Concrete Road Smoothed in Direction of Traffic

From Roads and Streets for March, 1934.

This concrete highway in Pawnee County, Oklahoma, is being constructed with the aid of a working force of 100 men. The interesting feature of this picture is the use of the longitudinal float operated lengthwise of the road from a bridge. This method of floating the concrete surface of this public works highway, built partly within an Oklahoma city, makes sure that any corrugations of the surface are parallel with traffic on the road. The finishing machine and the concrete mixer appear in the background. This work, begun September 30, is under the supervision of the Oklahoma State highway authorities and the U. S. Bureau of Public Roads.



The Longitudinal Float Is Operated Lengthwise of the Road

Brick Pavement Quantities, Specifications and Costs

The following data were supplied early in 1934 by G. F. Schlesinger, Chief Engineer and Managing Director, National Paving Brick Association, Washington, D. C.

Standard Sizes, Types, and Quantities.—Below are listed the varieties of paving brick recognized by the Permanent Committee on Simplification of the U. S. Department of Commerce, April, 1933. These varieties are subject to change at subsequent annual meetings of the Committee.

Sizes and Types of Paving Brick

Type	Size—Depth	Size—Width	Size—Length	Approximate Weight Tons per Thousand	Quantity Brick per Sq. Yd.
Vertical Fiber Lugless	2½"	× 4"	× 8½"	4	36
Vertical Fiber Lugless	3"	× 4"	× 8½"	4¾	36
Repressed Lug	4"	× 3½"	× 8½"	5¼	40
Wire Cut Lug (Dunn)	4"	× 3½"	× 8½"	5¼	40
Wire Cut Lug (Dunn)	3"	× 3½"	× 8½"	4¼	40
Vertical Fiber Lug....	3"	× 4"	× 8½"	4¾	36

Asphalt Filler Specifications.—The sampling and testing of asphalt filler shall be in accordance with the latest standard methods and requirements of the American Society for Testing Materials and/or the American Association of State Highway Officials.

(a) The asphalt filler shall be homogeneous, free from water, and shall not foam when heated to 177° C. (350° F.)

(b) Specific Gravity, 25°C./25°C. (77°F./77°F.)—not less than 1.00

(c) Flash Point—not less than 243° C. (470° F.)

(d) Softening Point (Ring and Ball)—not less than 75° C. (167° F.)

(e) Penetration—
At 0° C. (32° F.)—200 g., 60 sec.—not less than 15
At 25° C. (77° F.)—100 g., 5 sec.—30 to 40
At 46° C. (115° F.)—50 g., 5 sec.—not more than 90

(f) Ductility at 25° C. (77° F.)—not less than 4 cm.

(g) Loss at 163° C. (325° F.)—50 g., 5 hours—not more than 1.0%

(h) Total bitumen (sol. in CS_2)—not less than 99.0%

(i) Per cent of total bitumen insoluble in carbon tetrachloride—not more than 1.0%

Quantity of Bituminous Filler Required

(Surface Removal Method)

Depth of Pavement	Brick per Square Yard	Pounds of Filler per Square Yard
2½"	36	7.5
3"	36	9.0
3"	40	10.0
3½"	36	10.5
3½"	40	11.7
4"	36	12.0
4"	40	13.3

If the squeegee method of filler application is used, add about 1.5 pounds of filler per square yard to the quantities above. About 10 pounds of No. 9 (U. S. Std. sieve) gravel or stone chips per square yard for surface dressing also will be required.

Mastic Bed—Specifications for Bituminous Material.—Either tar or asphalt may be used in the preparation of the mastic cushion. If asphalt is used the contractor may select any one of the three grades specified or he may select any one of several grades intermediate between them. In selecting the grade of asphalt which will give the best results, consideration must be given to the characteristics of the sand used and to the weather conditions at the time the work is performed. The contractor will be expected to select the grade of asphalt which will give the best results.

The sampling and testing of bituminous materials shall be in accordance with the latest standard methods and requirements of the American Society for Testing Materials and/or the American Association of State Highway Officials.

(a) Tar. The material covered by these specifications shall contain only coal tar, carburetted water gas tar and/or products derived therefrom. The tar shall be homogeneous, free from water, and shall meet the following requirements:

Water—not more than 2.00%
Specific gravity at 25°/25°C.—not less than 1.09
Specific viscosity at 40° C.—8 to 13
Total Distillate, A.S.T.M. E. I. Flask:
Per cent by weight—
0-170° C.—not more than 5%
0-235° C.—not more than 20.00%
0-270° C.—not more than 35.0%
0-300° C.—not more than 45.0%
Softening Point (Ring and Ball Method) of Distillation Residue—not more than 60° C.
Specific Gravity at 38°/38°C. of total Distillate to 300° C.—not less than 0.96
Total Bitumen (soluble in Carbon Disulphide)—not less than 88.0%

(b) Asphalt. The asphalt cement shall be homogeneous, free from water, and shall meet the following requirements:

	Light	Medium	Heavy
(1) Furol Viscosity at 50° C.....	80–160	200–400	.....
Furol Viscosity at 60° C.....	.....	.....	275-400
(2) Distillation:			
(a) Distillate by volume			
To 225° C.—not less than....	12%	10%	3%
To 315° C.—not less than....	25%	20%	14%
To 360° C.—not more than...	40%	35%	30%
(b) The residue from the distillation to 360° C. shall meet the following requirements:			
Penetration at 25° C. (100 g.—5 sec.).....	70–110	70–110	70-110
Total bitumen (Sol. in CS_2)—not less than.....	99%	99%	99%
Ductility at 25° C.—not less than	60 cm.	60 cm.	60 cm.

Quantities for Bed or Cushion

	Mastic Bed		Plain Bed		
	Pounds per Square Yard		Pounds per Square Yard		
Depth of Bed	Sand	Bit. Matl. (5-8%)	Sand	Slag	Stone
½ inch	38	1.2 to 2.0	42	28	35
¾ inch	57	1.9 to 3.0	63	42	53
1 inch	76	2.5 to 4.0	84	56	70

Transportation, Loading, and Handling Costs.—For hauling paving brick and the other materials used in brick pavement construction use the local ton-mile rate for truck haul. The cost of loading and handling brick will be about $1.25 per thousand.

Labor Costs.—Following are average labor costs for brick pavement construction operations on projects of normal size using current P.W.A. labor rates:

Laying and rolling.....$0.08–$0.10 per square yard
Applying filler ..... 0.04– 0.06 per square yard
Laying and rolling plain bed.... 0.02– 0.03 per square yard
Mixing and placing mastic bed.. 0.04- 0.06 per square yard
Note: These average costs do not include overhead or profit.

Methods of Removing Surplus Filler in Brick Pavement Construction

In a paper presented at the 27th Annual Meeting of the National Paving Brick Association, Mr. O. W. Merrell, Director of the Department of Highways of the State of Ohio, described the work of his department on several experimental brick pavement projects in 1932. That portion of the paper relating to the removal of filler is reprinted herewith, having been published also in *Roads and Streets* for August, 1933:

To us the most important improvement in the technique of building a brick pavement has been the method for removal of surplus filler during construction. We have carried on some form of this treatment on a number of projects other than the experimental projects mentioned above, and feel that decisive results have been obtained.

Treatments to Prevent Adhesion.—This removal is accomplished by coating the brick just prior to the application of filler with one of three different mixtures: whitewash, calcium chloride in solution, or a patented mixture whose trade name is B & B. In the development of the whitewash and the B & B coating, it was the original intention to form a mechanical film on the brick, which would be allowed to thoroughly dry before the application of filler. With this treatment, it was expected that the surplus filler would readily crack off and be removed by traffic. On one or two projects, a power grader was used and about 80 per cent removal was accomplished. Further experimentation proved that all three agents mentioned are most effective when used purely as a moisture applying medium.

Whitewash Coating.—Let me quote from one particular project, built by a contractor who gave us excellent coöperation, and who took considerable interest in the development of this problem. On the major portion of this project the brick were coated with a thin whitewash consisting of 1½ sacks of spraying lime to 50 gal. of water. This whitewash was applied by means of a hand operated air pressure tank. The type of nozzle and amount of pressure were designed to produce a "fog" which would settle easily onto the surface, rather than being pressure jetted. With the nozzle kept 3 to 4 ft. above the pavement and a fine mist or "fog" of mixture produced, only the surface is coated, and the sides of the brick are untouched. The amount of lime is so small that the brick are scarcely colored, and serves more as a guide to the rate of application of moisture than for any inherent qualities as lime. In normal cool weather, the application of filler followed within 15 to 30 ft. This interval would necessarily be less during hot weather when the brick are dry and more rapidly absorb the moisture.

The asphalt filler was applied with coal scuttles and was simply emptied onto the brick, no attempt being made toward a careful operation. The brick were completely filled, resulting in a heavy coat on top, of from ⅛ to ¼ in. in thickness. Very little manipulation of the surplus coating on top was necessary, being restricted only to those portions where the brick were a trifle too wet, and a small amount of foaming thus ensued. For such localities, a lute similar to a cushion lute was used. No attempt was made to keep the top coating down to any thin film. In fact, the ultimate removal is more successful with a thick coat than a thin one. As the filler begins to cool, but before becoming brittle, workmen with hand sidewalk scrapers mark the coating into strips approximately 2 ft. wide, and then proceed to cut and roll up each strip, very much as a person would roll up a length of stair carpet. Two workmen with tools and one man rolling the material by hand make up a team. One half width of the pavement is filled and cleaned at a time, the filler being rolled from the edge to the center. Here the roll is left and subsequently picked up by the men who filled and operated the kettles. The operation is practically 100 per cent efficient, and leaves a pavement surface entirely free from filler of any kind. Repeated extraction of brick from the pavement so filled and cleaned failed to disclose any unsatisfactorily filled brick.

It appears that there are very few materials or operations that are 100 per cent foolproof or flawless, and the same thing occurs here. In the reheating of the surplus filler so removed, we have thus far specified that the mixture in the kettle be at least 50 per cent new material. The fly in the ointment with this whole process is that the rolling up of this carpet of filler takes with it whatever sand, brick dust, or surplus lime may be on the brick, which is thus introduced into the kettles. Our contractors found to their grief that it was necessary to clean their kettles daily to prevent burned out crown sheets. This is perhaps the most serious difficulty to forestall.

On this particular project there was one man applying whitewash, three men with coal scuttles applying, and six men removing filler. From the best of our records as to final quantity of filler used, it would appear that the value of the asphalt recovered through the removing operation about offsets the extra labor cost. In other words, we should now be able to build a clean surfaced brick pavement at the same price that we formerly paid for one on which surplus filler gave us trouble for two or three years.

Calcium Chloride.—The story with regard to calcium chloride is very similar as far as details of removal are concerned. Our experiments with this material have not been quite as extensive as with the whitewash. One method of application is by means of a roller having a cushioned or carpet covered surface on which the calcium chloride in solution is allowed to trickle. Thus the brick are treated with the calcium solution almost like a rubber stamp or blotting operation. The calcium has one advantage over the lime, particularly in hot weather, in that it does not dry nearly as quickly and hence more leeway in the application of the bituminous material is permitted. With whitewash this interval must be watched very closely, while with calcium it may be ten minutes or four or five hours, provided of course, that rain is not falling.

Special Mixture.—The third material is a patented material, but is essentially a flour and water paste. Like the other two materials the original intention was to permit a thorough drying before the application of the filler, and like the other two it has developed that the distribution of moisture is really the essential operation. In other words, all three materials are simply means of introducing a well-controlled amount of moisture between the brick surface and the filler. It is our contention, however, that this operation should be done carefully and by competent workmen, with extreme care that the sides of the brick do not become coated.

Resurfacing With Brick

The cross sections and descriptions here given are from an article by George F. Schlesinger, Chief Engineer and Managing Director, National Paving Brick Association, published in ROADS AND STREETS for January, 1933, pages 1-4. The article is based on a report to the Highway Research Board, December 2, 1932.

Design Features.—The design of a pavement structure for the resurfacing of an existing concrete slab with brick has been productive of variations in details. It is the almost universal practice to accomplish widening at the time the pavement is resurfaced. If the concrete is 18 feet in width, it is customary to use a 12-in. curb raised above the existing slab, on each side, providing a header for the new brick surface and making the total new pavement width twenty feet (Fig. 1). If the concrete width is less than 18 feet the practice varies. The total width of twenty feet can be attained entirely in the new concrete curb (Fig. 5); or the old slab can be extended with new concrete with an integral curb of standard dimensions (Figs. 2-3-4-6). The latter method is in greater use and has in its favor a more pleasing appearance because of a uniform width of brick surface and concrete curb; a greater effective travelable surface as vehicles are prone to keep off the curb.

In some cases a mechanical connection has been provided between the old slab and the new concrete widening with the object of preventing possible vertical displacement at the junction line. In one method the new concrete has been extended under the old slab a depth of 6 inches and a width of from 6 to 12 inches, with reinforcing (Fig. 6) or plain (Figs. 3-5). The Illinois section of 1931 (Fig. 5) also provided for a projection over the old slab, but this was changed in 1932 when the uniform 12 inch curb was adopted (Fig. 3). The 1932 design also economizes in concrete by using a beveled or sloping curb bottom. In the Illinois designs a continuous ⅞ inch round lubricated edge bar is placed in the new concrete curb. In one design used in Ohio, ⅝-in. by 18-in. round deformed anchor bars were inserted and grouted in the old slab (Fig. 2). This practice was later discontinued because of doubtful value and difficulty in construction. There is a difference of opinion as to whether a mechanical connection is worth the additional cost. Arguments against this practice are that the old compacted subgrade is disturbed and proper construction is difficult. Test cores taken in the Illinois work showed in general that the concrete was being forced under the slab satisfactorily although it was necessary to permit a slump of 4 to 6 inches.

In the Indiana standard section (Fig. 1) and in a majority of the projects constructed in Ohio (Fig. 4) no attempt has been made to join the new base or curb with the old slab. Ohio, which formerly made the curb 12 inches wide, has now adopted a 9 inch width as standard (Fig. 4). For reasons already given, this increases the surface that will normally be used by traffic.

Construction Methods.—The proper construction of the brick course itself presents no problems that are peculiar to resurfacing. In line with general practice lugless wire cut brick (vertical fiber) of 2½-in. depth has been used west of Ohio and 3 inch lub brick in Ohio. The type of lug brick, introduced about two years ago, that is meeting with almost universal favor is the vertical fiber lug. This differs from the old wire cut lug brick in having the wire cut side instead of the die side in the pavement surface. The recently developed "surface removal" method of filler application insures a clean brick surface immediately after completion.

There is a divergence of practice in the method of correcting irregularities in the old slab and in the type of bed or cushion course. The method used in the former is to some extent dependent upon the type of material in the cushion. A plain sand cushion should not vary in the thickness and the base should be brought to a true cross section. For granulated slag—which has cementing properties—sand cement and bituminous mastic bed, a variation of ¾-in. to 1½-in. is the usual tolerance permitted. For correcting large irregularities, a cement sand mortar—1:3 proportions—is the material commonly specified. Bituminous concrete has also been used.

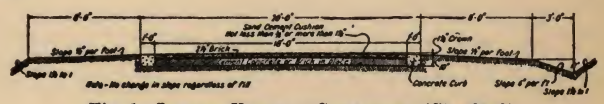


Fig. 1—INDIANA HIGHWAY COMMISSION (Standard)

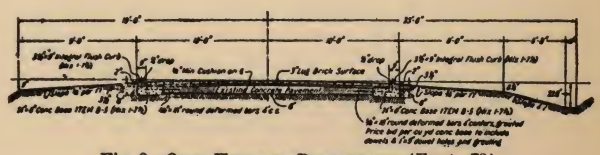


Fig. 2—OHIO HIGHWAY DEPARTMENT (Route 73)

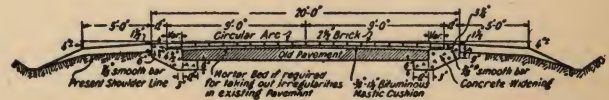


Fig. 3— ILLINOIS DIVISION OF HIGHWAYS (1932 Standard)

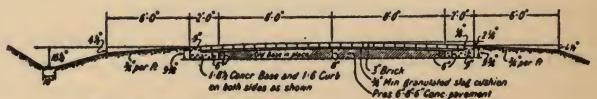


Fig. 4— OHIO HIGHWAY DEPARTMENT (Route 3)

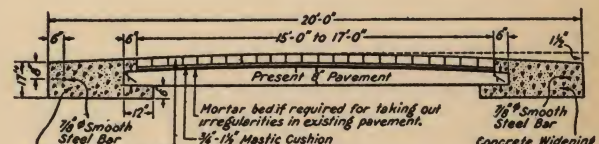


Fig. 5—ILLINOIS DIVISION OF HIGHWAYS (1931 Standard)

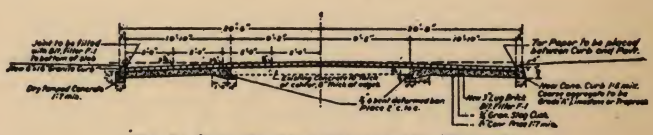


Fig. 6- -OHIO HIGHWAY DEPARTMENT (Route 8)

The function of mortar or bituminous materials used in correcting irregularities in the old slab is as a filler for shaping up and not to add structural strength. Being confined under the brick course, and cushion proper and between the curbs, there is little opportunity for displacement even if cracking occurs.

The development and extensive use of the bituminous mastic cushion has been coincident with the brick resurfacing program in Illinois. In sections of the country where granulated blast furnace slag is not economically available mastic cushion is recommended for all brick paving construction. It is stable but resilient, will not sift down into small cracks, has water proofing qualities and would seem to be especially applicable to brick resurfacing construction.

In the resurfacing constructed in Illinois in 1931 ex-

pansion joints, extending the full depth of the pavement, were placed. They were 4 inches in width at about 1,000 foot intervals and filled with asphalt. It was also the practice to locate them at points where "blow-ups" had occurred in the old slab. In the projects constructed in 1932 this feature of design has been eliminated. This conforms to general practice for brick surface construction as transverse expansion joints have not been found necessary with a bituminous filler.

It is the general practice to require that all cracks in the concrete in place be thoroughly cleaned and filled with bituminous material. The excavation for the widening curb would appear to present difficulties especially for the beveled section used in Illinois (Fig. 3). Their specifications require that "all loose earth shall be removed and any excavation outside the dimensions shown on the detailed cross-section shall be filled with concrete at the contractor's expense." However, contractors have been very ingenious in devising equipment to cut the sections without hand labor. It is accomplished by several trips of a tractor drawn excavator which has changeable cutting blades.

Resurfacing of Concrete Bases

In the form that this type of reconstruction usually takes it is really a replacement operation. That is, the condition of the original surfacing material having become unsatisfactory, it has been removed and replaced with a new surface course after the old concrete base has been properly rehabilitated. In the case of brick pavements, in some instances, the old brick (or a portion of them), after removal, have been relaid on the existing concrete base. There are also projects where a new brick top course has been laid on an old two-course concrete base pavement without removal of the original surface. This may be considered as resurfacing a concrete base although there is an old intervening course.

Base Preparation.—The question of the adequacy of the old base in place arises as in the case of resurfacing concrete pavements. It can likewise be advanced that, similar to an old pavement, an old base has inherent attributes in its favor. City streets differ from highways in that, because of underground drainage systems the subgrade conditions are usually more favorable; also established curb grades in most cases limit or preclude raising the elevation of the new surface.

Concerning the concrete bases in Lima, Ohio, on which large areas of brick pavements have been salvaged and relaid there is the following comment:

"If the base is bad in places we replace and properly re-enforce it, so there will be no danger of settlement. We do not feel especially concerned about the quality of the base. That base has been in there for twenty-five or thirty years and we feel that its weakness, if any, has been revealed long since. The ground beneath it is established and hard-packed, and we do not feel there is any chance for the base to settle any more except in case of service cuts."

Gutter Construction.—On concrete base resurfacing projects, it is frequently impossible—or undesirable from the standpoint of economy—to raise the old curbs to provide sufficient gutter. In some cases the original curb height was ample to allow for additional surface depth. When this is not the case and the new surfacing is brick, the difference to be taken care of can be eliminated or minimized by the use of a tapered or wedge shaped brick at the gutter line. Such a brick for example would taper from 3 inches at one end to 2½ or 2 inches at the other. Several courses of thinner brick are then laid at the curb to give the required gutter section. If necessary, the depth of cushion course can also be decreased—one-half inch being quite feasible especially with bituminous mastic.

Relaying Brick on Concrete Bases.—There is no difference between this type of resurfacing and what has been referred to previously as replacement except that instead of new material for the new surface course the old brick are re-used in whole or in part. Brick is unique in this respect among manufactured paving materials. Of course, new filler and usually new bed material are required.

In most of the old brick pavements, the brick were laid "on edge," that is, with the greater cross-sectional dimension vertical. When relaid they are usually laid flatwise, according to present day practice, and there is a gain in surface area. This fact affects the percentage of salvage measured by the area covered by the relaid brick. In some cases this has actually resulted in a salvage greater than 100 per cent and a surplus of brick which were used for additional paving. The general average is 75 to 80 per cent. Due to the increase in manufacturing costs since the brick pavements were originally constructed 20 to 30 years ago, the relay value of the brick is in many cases materially greater than the original cost.

Summary

1. Resurfacing of concrete pavements has to date had its principal application to concrete highways not streets. Illinois has resurfaced about 120 miles in the last two years.

2. Old concrete slab should be adequate structurally or properly strengthened before resurfacing.

3. The stability developed in the old pavement structure through the years of its existence with proper maintenance is an important advantage.

4. Reasons why resurfacing increases service value are not primarily structural.

5. Design details vary principally because of the method of accomplishing widening and the desirability of connecting the curb and widening with the existing slab.

6. Materials used to correct irregularities in old slab act as a filler.

7. Bituminous mastic bed is especially applicable.

8. Expansion joints in brick pavement with bituminous filler are not considered necessary.

9. Excavation for widening curb can be performed with power drawn equipment.

10. Cost data of brick resurfacing over concrete, as such, can not be segregated from items not primarily inherent to the resurfacing operation.

11. Concrete bases have been resurfaced with brick by replacing old surfaces, by relaying the old brick, or with a new brick surface over an old two-course pavement.

12. Adequacy of the old base must be considered.

13. Examples of brick resurfacing over two-course pavement not numerous.

14. Tapered brick and thinner cushion can be used at gutters.

15. Cost of removing, cleaning, and relaying brick varies with labor wages and type of filler.

16. Salvage averages 75 to 80 per cent with 100 per cent in some cases due to gain in area.

17. Costs for relaying have been as low as $0.50 per square yard.

18. Existing pavement should be resurfaced when it has attained its economic life.

19. Brick resurfacing must justify itself on economic grounds.

Miscellaneous Block Pavement

Specifications, Maryland State Roads Commission

Paving Around Inlets.—Wherever indicated on the plans, in conjunction with a bituminous or other pavement, a double row of new hole block of the character designated shall be laid around the grate frames or drip-stones of grate-top and open-mouth inlets, respectively, directly on the concrete before it has developed initial set, unless otherwise indicated or directed. The near edges of the blocks adjacent to the inlet structures shall be flush with the grate-top or drip-stone, from which point the surface of the blocks shall slope upward uniformly, at a rate of not more than 1¾ inches to the foot, to the finished surface grade of the pavement. Spaces between the blocks shall not be less than ⅛ nor more than ½ of an inch in width, depending on the kind of block used, and the blocks shall be laid to break joints by not less than 3 inches. The spaces between the blocks shall be filled as indicated. This paving shall be done with similar materials and in accordance with the specifications contained herein for the kind of blocks used, except as noted above. Where and whenever necessary, drip-stones shall be reset, without additional compensation, at such grade as will afford a uniform open-mouth of 6 inches in general depth, except when directed otherwise.

Placing Railway Track Block Liners.—Where indicated on the plans, in conjunction with a bituminous or other pavement laid adjacent to the tracks of a street railway, a double row of new whole block of the character designated shall be laid adjacent and parallel to each edge of each rail, directly upon the concrete foundation before it has developed initial set. The blocks shall be laid to meet the railsurface or to be slightly below, as indicated or directed. The rail shall conform to the established grade of the roadway. The blocks shall be backed thoroughly with concrete tamped carefully to a firm bed. Spaces between the blocks shall be not less than ⅛ nor more than ¼ of an inch in width, depending on the kind of blocks used, and the blocks shall be laid to break joints by not less than 3 inches. The spaces between the blocks shall be filled as indicated. This paving shall be done with similar materials and in accordance with the specifications contained herein for the kind of blocks used, except as noted above.

Placing Railway Rail Channel Filler.—Prior to laying any pavement or liners adjacent to a street railway track, the spaces between the web of the rail and the blocks shall be filled with cement mortar composed of 1 part of Portland cement and 2 parts of fine aggregate conforming to the requirements for "Plain Cement Concrete Pavement." The mortar shall be in a plastic condition and the exposed surface of the filling shall be smooth and conform to a straight line before the blocks are laid. Bituminous expansion joint filler, conforming to the requirements of the Engineer, shall be used in the spaces between the rail filler and the block.

Basis of Payment.—Paving around inlets and railway track block liners will be paid for at the contract unit price per square yard for "Vitrified Brick Pavement," or "Stone Block Pavement," as the case may be, complete in place, which price will include all materials, equipment, tools, labor and work incidental thereto.

The "Railway Rail Channel Filler" specified above will not be paid for directly, but will be included in the contract price per square yard for the completed pavement.

Stone Curbing

Specifications, Massachusetts Department of Public Works

Description.—Stone curbing shall be set to the required line and grade on a bed of gravel and in accordance with these specifications.

Materials.—All stone curbing shall be hard and durable, free from seams, bunches and depressions, or other imperfections, shall be of uniform color throughout and shall have horizontal beds. The stones shall be cut to lengths of not less than six (6) feet and shall be seven (7) inches wide on top and not less than seventeen (17) nor more than nineteen (19) inches deep. The top of the curbstones shall be out of wind. They shall be peen hammered on top and the front and back edges shall be pitched true to line with no projection on the back face greater than one (1) inch for three (3) inches down from the top. The front face shall be straight split, free from drill holes and with no projection greater than one (1) inch for a distance of ten (10) inches down from the top. The ends shall be squared with the top for the depth of the face finish and so cut that they can be set without mortar in joints of not more than three-eighths (⅜) of an inch. The bottom of the curb shall be not less than five (5) inches in width.

The cement, water and sand shall conform to the requirements of Section 92. The gravel shall conform to the requirements of Section 16. [Not quoted here.]

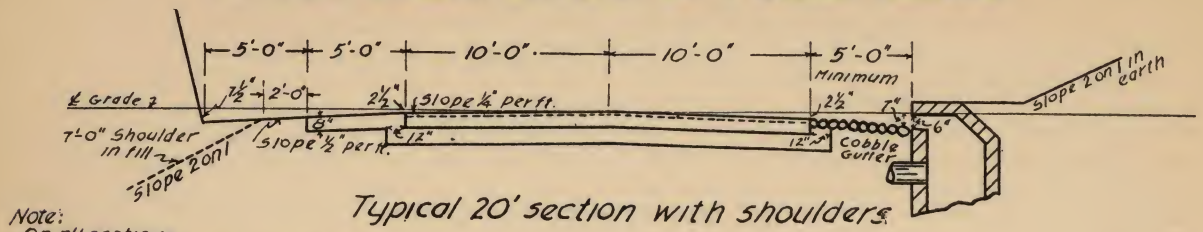
Construction Methods.—The stone curbing shall be placed to the required line and grade on a gravel foundation in a trench. The trench for the stone curbing shall be eighteen (18) inches wide and its subgrade shall be twenty-four (24) inches below the top of the finished stone curbing.

Upon this subgrade a foundation shall be made, consisting of good, clean, coarse gravel, thoroughly rammed so that it will be four (4) inches thick when completed. Upon this foundation other gravel of the same kind shall be spread, the stone curbing laid therein, the joints made as close as possible, and all the spaces under the stone curbing thoroughly filled with gravel and tamped so that the stone curbing will bear throughout its whole length and be at the line and grade required. The stones shall project seven (7) inches above the shoulder grade or pavement, unless otherwise directed or called for on the plans.

The joints between the stone curbing shall be carefully pointed top, front and back, with mortar made of equal parts by volume of Portland cement and clean sharp sand. The trench shall be backfilled with gravel to the depth ordered and thoroughly tamped, care being taken not to affect the line or grade of the stone curbing.

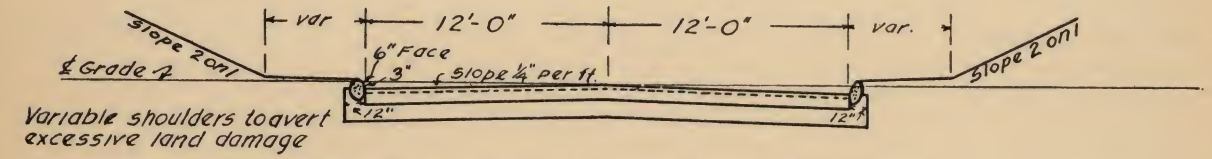
Basis of Payment.—This work will be paid for at the contract unit price per lineal foot of stone curbing, complete in place, which price shall include all materials (except gravel borrow used for foundation and backfilling), all excavation (except ledge), and all work incidental thereto.

Standard Bituminous Pavement Sections
Rhode Island Board of Public Roads

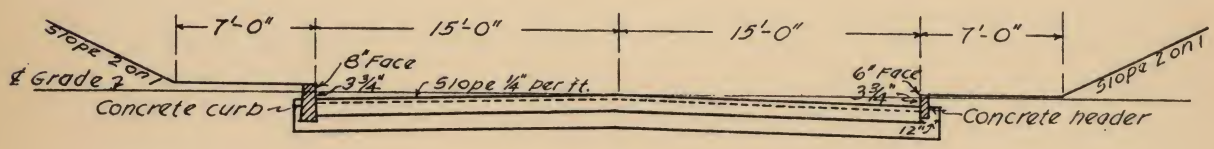


Typical 20' section with shoulders

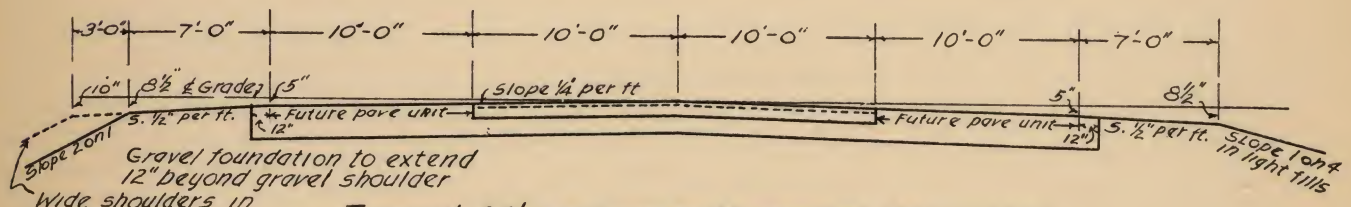
Note:
On all sections
2½" Bituminous top course
5½" Crushed stone base course
Foundation as ordered



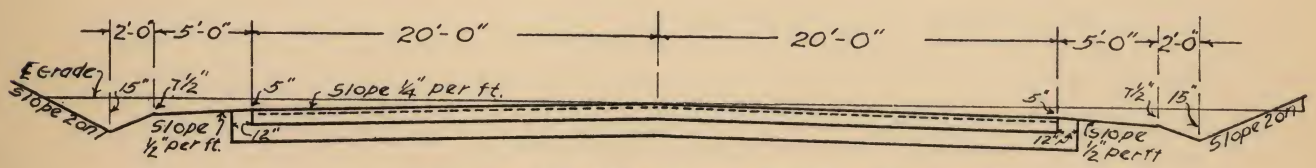
Typical 24' section with stone headers



Typical 30' section with concrete curb or header



Typical 20' section with gravel shoulders



Typical 40' section with shoulders

Relation of Traffic Volume to Degree of Improvement

From Asphalt Road Construction Manual No. 2

As a result of thorough traffic studies, it has been definitely established that the following surfaces can be built for varying traffic conditions and earn their cost and upkeep:

0 — 100 vehicles daily—Natural earth surfaces, graded and drained.

100 — 300 vehicles daily—Selected materials for surfacing, such as top-soil, sand clay, shale, chert, red dog, etc.

300 — 500 vehicles daily—The best selected materials and gravel, sometimes with surface treatment.

500 —1,500 vehicles daily—Surface treatment on the above mentioned materials, and road-mix surfaces.

Over 1,500 vehicles daily—Asphaltic concrete, asphalt penetration macadam, sheet asphalt or sand asphalt, concrete, brick.

Most roads are included in the four groups under 1,500 vehicles daily,—which include the entire secondary system of highways as well as a very substantial portion of the so-called "primary system." On the basis of mileage to be economically improved, therefore, it is clearly evident that the subject of surface treatments is one of the greatest importance, as by such methods the majority of roadbeds may be made suitable for year-round traffic for many years to come.

Surface Treatment of Natural Soils

The discussion here given is condensed from Manual No. 2 of the Asphalt Road Construction Series issued in 1933 by The Asphalt Institute, 801 Second Ave., New York, N. Y.

In the following discussion of surface treatments on dirt roads, let it be understood at the outset that these are not temporary surfaces but real all-weather roads, where adequately prepared and maintained. They are in decided contrast to the so-called oiled earth roads using dust-layers, where the improvement is of short duration. Properly treated earth roads are good roads, capable of carrying heavy loads and relatively heavy volumes of traffic at high speeds, if drainage is properly provided and the necessary amount of asphaltic material is correctly applied.

By natural soil subgrades is meant the kind of earth surfaces known to everyone as just plain dirt roads. The gravelly subgrades which are practically similar to selected gravel surfacing, the naturally balanced mixtures of sand and clay which are in reality the same as the artificial sand-clay roads and other naturally high-grade supporting surfaces are not included in this discussion of treatments on such dirt roads. The treatment of dirt roads is often one of the borderline cases, being in some cases a simple surface treatment and in others a combination of surface treatment and road-mix, where several surface treatments are given several months apart, each one being preceded by scarifying the mat previously obtained, so that depths in excess of one inch finally result. The selection of method varies in accordance with the character of the soil.

Silt Soils.—Silt, silty loams and silty clays, wherein the silt is the predominating constituent, make the most unstable kinds of dirt roads. The unconfined material has very little cohesion between the particles and only a very small amount of internal friction, with the result that under conditions of rain and wind, erosion is rapid and any untreated road surface quickly deteriorates. When confined, however, these silty materials develop considerable stability and, by the proper use of an asphaltic material incorporated with them to produce this condition, a good durable surface may be built up. The method of procedure is as follows:

Preparation of the Road Surface.—Early in the spring the road surface is carefully bladed to a true and even cross-section. The greatest pains are taken to insure a uniform condition of surface. As in every other type of surface treatment this preparation of the surface is all important. Due to the rapid loss of moisture from silty soils in hot weather, it is desirable to do the final blading of the surface immediately in advance of the application of the asphaltic material—the same day if possible. By so doing the upper layer of the roadbed is made slightly moist, which causes a bulking of the earth thus permitting the ready absorption of the asphaltic material. In the event that the roadbed has dried out and become dusty, the loose dry material should be bladed to the side of the road to expose the relatively moist material underneath, thus approximating the ideal condition as nearly as possible. Where the application of the asphaltic material is made to a loose dusty surface there later will occur ravelling and stripping, due to the movement of this loose material under the treatment.

Application of Asphaltic Material.—Upon the firm moist roadbed thus prepared is applied the asphaltic material at the rate of 0.5 gallon per square yard, which is allowed to be entirely absorbed without any cover coat. Where practicable, the road is closed to traffic during the time required for absorption so that the entire roadway width may be treated at once. Where detouring is not possible, the application is made to one-half the roadway and traffic directed on the other half while the asphaltic material is soaking in. Care should be taken to keep traffic off the freshly treated surface for several reasons, viz.: to permit uniform absorption; to prevent tracking and cutting the new surface; and also to prevent splashing of passing vehicles. There is no excuse for the careless driver to operate his car over the newly treated surface and a little police patrolling will completely take care of the matter. In this connection, the use of a highly penetrative asphaltic material is important, as the time required for complete absorption is reduced to a matter of a few hours instead of the several days formerly needed. The specifications for the recommended asphaltic material, known as liquid asphaltic road material MC-1, are given at the end of this article. This material is usually applied cold, with normal summer temperatures, or may be warmed to not over 140° F. in cool weather to obtain better uniformity. Even at summer temperatures a slight warming is frequently desirable.

As soon as the first application is completely absorbed, a second application is made at the rate of 0.25 gallon per square yard and permitted to soak in as before without any cover coat. In the occasional places where a pool forms, due to a depression, the surplus asphaltic material is blotted up by a light covering of earth. This, however, is to be avoided to every possible extent by careful blading before the original application so that no depressions may be present. Traffic is then permitted to use the surface and, under the kneading action of pneumatic tires, there is shortly developed a tough leathery surface which is waterproof, resilient and smooth.

For first year treatment, a third application of 0.25 gallon per square yard is applied a short time afterward (several days to several weeks, according to the appearance of the surface) to insure the complete admixture of asphaltic material with all earth particles near the surface, making a total of one gallon per square yard in all. This is likewise allowed to be absorbed without any cover coat. Where a road is completely closed to traffic, the three applications are made as rapidly as each one is absorbed; while when applied one-half the roadway width at a time, they are given as rapidly as convenient. Earlier treatments were of lesser amounts, but experience has demonstrated that on silty soils one gallon per square yard is necessary to obtain complete penetration.

The entire roadway width should receive the asphaltic material so that traffic will not track untreated earth over the treated surface. At intersections with untreated roads, the treatment should be given also to the side road for a distance of 25 to 50 feet for the same reason. The continued admixture of earth to a treated surface tends to deaden the mat and lead to ravelling, all of which can be prevented simply by extending the treated surface beyond the normal traffic lanes.

Patching Material.—Any areas that ravel or become broken and depressed are repaired by patching, using a mixture of earth and liquid asphaltic road material MC-1. Such a mixture should be made up and stockpiled at the time of the original treatment, after which it slowly cures and may be kept indefinitely. Another method of making patching material, as developed by Missouri, is as follows: dig a shallow pit near the roadway where

borrow may be obtained, fill it with asphaltic material and let it soak into the earth until completely absorbed. The saturated mixture may be taken out then as needed. This method has the advantage of making the mixture readily available the year around, as it does not freeze and also as there is no labor involved in the mixing.

Retreatment.—The second year a retreatment will be required. This consists of regrading and smoothing the surface, followed by two 0.25 gallon application of liquid asphaltic road material MC-1 in the same manner as in the original treatment. A relatively new piece of equipment, the Killefer disk, is being used most successfully for scarifying the surface prior to the reblading operations. This machine consists of four sets of steel disks placed in a frame and set at a slight angle to the center line of the road, so that the weight rests on the disks. These disks turn as the machine proceeds, resulting in a row of narrow longitudinal cuts produced by shearing action. A multiple blade maintainer follows immediately thereafter, mixing the loosened material and filling depressions. This operation is followed by a thorough blading of the surface to achieve a proper cross-section and profile. The application of the asphaltic material should follow soon after and the loosened and rebladed material will all rebind in its new position to make a smooth, tough, resilient surface.

Summary of Surface Treatment Operations on Silty Soils

First Year—

1. Preparing surface by careful blading and dragging.
2. Final blading immediately before first application of asphaltic material.
3. First application using liquid asphaltic road material MC-1, rate 0.5 gallon per square yard, and allowing to be absorbed *without cover.*
4. Second application of liquid asphaltic road material MC-1 at rate of 0.25 gallon per square yard, as soon as first application is completely absorbed.
5. Several weeks later, a third application, using 0.25 gallons per square yard, a total of one gallon in all.
6. Making repairs by using mixture of earth and liquid asphaltic road material MC-1.

Second Year—

1. Application of 0.25 gallon liquid asphaltic road material MC-1—no cover.
2. Second application at rate of 0.25 gallon liquid asphaltic road material MC-1—no cover.

Costs.—The costs of treatment and maintenance the first year average from $400 to $600 per mile; the retreatment the second year approximately $300 per mile, with subsequent retreatments averaging about $200 per mile per year. These costs include all maintenance charges and such items as preparing the grade, furnishing and applying asphaltic material, patching, etc.

Suitability of Traffic.—The late D. O. Thomas, Superintendent of Highways, St. Clair County, Illinois, has aptly described the required conditions for such treatments and the necessary steps of procedure. He said, "The most important part of road oiling is the proper preparation of the earth road before the oil is applied. I would say that the success of an earth road surface treatment is ninety per cent preparation of the surface and ten per cent the balance of the treatment and finishing. The oiled portion of the roadway should be at least sixteen feet wide to discourage the practice of driving with one set of wheels on the unoiled portion. The more friable and silty the soils, the heavier the treatment required. The proportion of pneumatic-tired traffic to solid-tired traffic, or steel-tired traffic, is important. Steel tires, especially if narrow, are prejudicial to oiled earth surfaces and, accordingly, not over 10 or 20 per cent of the traffic should be of this character. Where the pneumatic-tired traffic is 80 per cent or more of the total, then the ironing-out effect of the rubber tires will overcome any cutting down by steel tires. Snow is the worst enemy of an earth road and provision should be made for removal of snow from the oil surface as soon as possible after its falling."

Clay Soils.—The term "clay soils" is applied to those dirt roads that are composed principally of clay particles, with the other constituents of silt and sand present in such small quantities as to have little or no effect upon their behavior. There are many different kinds of clay but, for the purpose of surface treatments, they fall into two classes according to their capillarity—that is, their ability to draw up water from the ground water level underneath the road surface. The two groups are described as follows: one, the non-capillary group composed of finely divided clays so constituted as not to permit the rise of capillary moisture more than a few feet; the other, the group in which the internal structure of the soil permits the capillary rise of water to heights of from 10 to 200 feet. These different kinds of clay, when used in road building, show little difference in behavior under the admixture of surface water, both groups becoming more and more plastic with additional moisture until they are equally impassable. Under such conditions the effect of capillary water is hardly discernible. However, when the surfaces are waterproofed by an asphalt coating and the roadbed has become thoroughly consolidated, the non-capillary clays will maintain their stability all the year around while the highly capillary ones still show more or less break-up because they still become saturated and plastic from the rise of ground water.*

There are many miles of low-capillary clay roads now being successfully and economically surface treated by methods which are applicable over a wide area. Included among these non-capillary clays, for example, are some of the gumbo soils in the middle west, notably in Minnesota and adjacent states, long famous as particularly bad roads in wet weather—until it was learned how to treat them without going to the expense of a high-cost pavement. The method, locally termed the "blotter treatment," or asphaltic mulch surface, was evolved after many experiments using untreated aggregates only in the endeavor to build up gravel surfaces. Due to the highly plastic nature of this soil, untreated gravel was gradually absorbed during wet weather, in some instances to as much as six feet below the surface and, of course, rapidly lost its supporting value. The first "blotter treatment" was applied in 1925, using asphaltic materials, with results which were amazing.

It was quickly demonstrated that, when adequately drained, thoroughly consolidated and then given a surface treatment followed by a light gravel cover, these gumbo roads would give good year around service for traffic as high as 1,500 vehicles daily, the average being from 500 to 800. The essential steps are as follows:

Method of Treatment (Non-Capillary Clays).—The proper preparation of the surface is all important. Early in the spring the road is bladed and dragged to obtain maximum consolidation and density, as well as a true cross-section and profile. The final blading is finished just soon enough before treatment operations begin so that traffic may iron out the surface to the smooth, rub-

**Test for Capillarity.*—A number of tests have been devised for the determination of relative soil stability, and the reader is referred to either the U. S. Bureau of Public Roads or his own State Laboratory for further information in this regard.

bery character which is typical of such soils. The first application of asphaltic material is at the rate of 0.3 gallon per square yard. This is allowed to soak into the surface without any cover coat in order to thoroughly impregnate the upper part of the roadbed and provide a complete bond with the seal coat and gravel cover. For this priming operation liquid asphaltic road material MC-1 is recommended, because it has the ability both to penetrate the dense surface and to establish a definite asphalt cement binder after such penetration has been accomplished.

The second application is then made at the rate of 0.3 to 0.5 gallon per square yard; this is covered with 50 pounds of gravelly sand; and then the surface is bladed until the gravel and asphaltic material are thoroughly mixed. To meet the need for occasional blading of the surface after treatment and the prevention of any cracking of the mat, a non-hardening asphaltic material is recommended, known as liquid asphaltic road material SC-2. The mat so formed is dense and impervious to surface water, yet sufficiently flexible to permit such reblading as may be needed to correct depressions and prevent the formation of any cracks or crevices, should the clay subgrades move slightly in further compression. Once this settlement has been completed, further maintenance is by blading or patching occasionally as needed. If an area ravels the loose material should be removed and the patch made with a mixture composed of liquid asphaltic road material SC-2 and the same kind of aggregate previously used for cover coat. This treatment will carry through the first year, with but few break-ups during the winter.

Summary of Surface Treatment Operations on Non-Capillary Clay Soils

1. Careful preparing of surface by blading and dragging.
2. Priming the surface using liquid asphaltic road material MC-1 at the rate of 0.3 gallon per square yard, without cover.
3. Second application, using liquid asphaltic road material SC-2 at the rate of 0.3 to 0.5 gallon per square yard.
4. Covering with 50 pounds of gravelly sand, followed by blading and dragging until thoroughly mixed.
5. Reblading as needed to maintain smooth surface.

Retreatment.—The following spring a retreatment is advisable. The road is first carefully bladed and smoothed, using both motor graders and multiple blade maintainers. Any broken areas are repaired by patching. Liquid asphaltic road material SC-2 is then applied at the rate of 0.2 to 0.3 gallon per square yard, according to the amount needed to renew the live condition of the mat, followed by a cover coat of gravelly sand at the rate of 10 to 20 pounds. The surface is then again bladed and dragged to insure thorough mixing and consolidation. Thereafter, treatments are required about every other year, at about the same rate, and with cumulative betterments as the years go by.

Costs.—The initial treatment costs from $1,200 to $1,500 per mile and annual maintenance, including all retreatments, averages around $500 per mile. These figures are based on treated roadway widths from 25 to 32 feet, and for an 18-foot surface would run proportionately less. A marked factor in reducing maintenance costs, as well as extending the interval between treatments, has been the new high line profile in making new roadways. This raises the road surface so far above the ground water-levels that even moderately capillary soils may be treated successfully, while those of low capillarity are thereby so dried out that even under the severe northern winters with as much as six feet of frost the resulting volume change between a thawed and a frozen condition is of small amount.

Treatment of Highly Capillary Clays.—The treatment of highly capillary clay soils presents the most difficult problem in surface treatment work, as it also does in any form of more expensive paving. Such soils even though waterproofed from above, may still become saturated from the rise of ground water and become completely impassable. The surface treatment as described in the preceding paragraphs will help but, under severe winter conditions, a considerable amount of break-up will take place and there is rarely any cumulative betterment. The large mileage of this kind of road surface, however, and the absence of suitable aggregates for surfacing, closely available at reasonable cost, indicate the desirability of further intensive study and research to solve this difficulty.

Several promising experiments have been made, principal among them being the treatment of two different levels of the surface, which in effect makes a slab of earth surrounded by asphalt.

A method already in successful operation in several states is that of incorporating a coarsely woven cotton fabric (mesh ⅛ inch by ¼ inch) in the asphalt surface treatment. Briefly, the procedure is to prime the surface with asphaltic material, place the fabric in long strips on the surface, then apply the heavy asphaltic seal coat, cover with aggregate and roll. The fabric as impregnated with asphalt is completely durable and tends to reduce ravelling and breaking of the mat under softened subgrade conditions. The first work of this kind was placed in South Carolina in 1926-1927, followed by other projects in Texas in 1930, in Sheffield, England, 1930, in Georgia, 1931, and in Louisiana, 1932. The cost of the fabric in place is about eight cents per square yard and there are undoubtedly many locations where such reinforcement will prove an economical procedure. The Cotton Textile Institute, New York City, is carrying on further studies in this field.

The practice of modifying the character of certain clay soils by the addition of small amounts of granular material, such as gravel, stone, slag and cinders, is highly successful. Under certain conditions the admixture of as little as one inch depth of such aggregates will reduce the capillarity of a soil sufficiently to make the surface treatment method entirely effective.

Sandy Soils (Not Including Pure Sands).—Dirt roads largely composed of sand, such as sandy loams and sandy silts, constitute the remaining class. These are earth roads, easiest to treat and, as there has been long experience in such treatment, the technique is thoroughly developed. Many of the early California roads were of this character and have been brought to a high state of excellence—many of them closely resembling sheet asphalt or asphaltic concrete surfaces and carrying traffic averaging 1,500 vehicles daily.

Sandy soils are quite unlike the silts and clays previously described, and the treatment with asphaltic material is slightly different. The initial preparation of the roadbed is the same, care being taken to have adequate drainage and uniformity of surface, and continuous blading is carried on during the early spring to obtain the smooth, even, cross-section and profile required. As silt and clay soils become tightly bonded when moist the asphaltic material is absorbed without requirement of cover. In contrast, sandy soils are somewhat loose, consequently requiring a cover and some mixing to insure the same degree of stability. The procedure is as follows:

Method of Treatment.—After the roadbed has been carefully conditioned and just before the first application

of asphaltic material, a small amount of earth is bladed to the side of the road in a windrow, approximately one inch of depth being usually enough. Liquid asphaltic road material SC-2 is then applied at the rate of 0.6 to 0.8 gallon per square yard and immediately covered by blading back the earth previously removed. One-man grader outfits or tractor-drawn graders are usually employed and the blading is continued until the surface is smooth and even. The oil gradually absorbs this cover but, if bleeding occurs, additional earth is applied to absorb it. An excess covering of earth should not be used as it makes a crumbly mat. As pneumatic-tired traffic soon irons out the surface, it is a peculiarity of this type of treatment that traffic consolidation is better than rolling.

As soon as traffic begins to break through this first application, which usually will be in about one or two months, the surface should be scarified and pulverized to a depth of two or three inches. It then should be rebladed and made uniform, followed by a second application of liquid asphaltic road material SC-2, covered with earth and manipulated as in the first treatment. This second application will vary from 0.5 to 0.8 gallon per square yard, depending upon the character of the soil, viz.: the amount of clay or silt particles present in the sand which affect the absorption of the asphaltic material. The finer the texture of the soil the greater the quantity required. The ideal mixture will be quickly determined by inspection after a few days' traffic. Too little will produce a crumbly surface; an excess will make a fat surface. Either condition may be quickly remedied, however, either by a light additional treatment in the first instance or scarifying and reblading in the second one. Usually two applications are sufficient for the first year and the following winter will find the road surface supporting traffic in a much improved condition as compared with the untreated surface. There will be a certain number of places which will break through, due either to water pockets or to certain non-uniform areas. The method of maintenance is to drain away the water and fill the depressions with a mixture of oil and earth.

The next year the same procedure of treatment is again followed and, before the second winter, an impregnated layer of earth and asphaltic material, approximately four inches thick, will have been built up. Subsequently additional applications of asphalt are given as conditions require, the whole procedure being carried on with view to building up gradually a dense, waterproof surface over a period of two or three years, so that thereafter the annual maintenance will be limited to an occasional patching of small areas. Under favorable climatic conditions this maintenance will be little greater than for standard pavements, with retreatments required at intervals of three or four years. Under severe frost conditions it may be desirable to retreat every two years at a rate not to exceed 0.5 gallon per square yard, with view to resmoothing a surface because of deformation due to heaving rather than to any failure in the surface itself.

Summary of Surfacing Operations on Sandy Soils

1. Careful preparation of surface by blading and dragging.
2. Blading to roadside about one inch depth of surface just before initial application of asphaltic material.
3. Application of about 0.7 gallon per square yard liquid asphaltic road material SC-2.
4. Blading back of earth previously removed, and continuance of blading until surface is smooth and even.
5. Several months later, scarifying of surface, reblading and repeating of operations one to four.
6. Making small repairs by patching with a mixture of earth and liquid asphaltic road material SC-2.
7. Making retreatments as necessary.

Costs.—The costs of treatments vary from $250 to $500 per mile for an 18-foot width for the first year, but by the third year they will have dropped to amounts ranging from $50 to $100 per mile as the surface becomes stabilized. There is definite cumulative betterment with each subsequent treatment, as drainage is perfected and all areas are made uniform in character. In many cases with roadbeds thus treated over a period of years, where traffic increases in large volume so that heavier wearing surfaces are required, it is practicable to use this prepared subgrade as a foundation for an asphaltic concrete or a penetration macadam wearing course without any further strengthening, because of the inherent stability in such surface treated sandy soils.

Quantities of Aggregate for Use With Tar Binder

The accompanying table of quantities of aggregate required for tar binder surface courses is from *Low Cost Roads and Bridges* by Victor J. Brown and Carleton N. Conner.

	FINISHED SURFACE			BOTTOM COURSE				TOP COURSE			
Aggregate	Thickness in In.	Wt. Lb. Per Sq. Yd.	Sq. Yd. Per Ton	Size of Mix	Loose Depth in Inches	Wt. Lb. Per Sq. Yd.	Sq. Yd. Per Ton	Size of Mix	Loose Depth in Inches	Wt. Lb. Per Sq. Yd.	Sq. Yd. Per Ton
Trap or Granite	1	114	17.5	.....	...	...	....	Fine	1½	114	17.5
	2	230	8.7	Interm	2¼	154	13.0	Fine	1	76	26.3
	2¼	247	8.1	Interm	2½	171	11.7	Fine	1	76	26.3
	2½	266	7.5	Coarse	2¾	190	10.5	Fine	1	76	26.3
	2¾	301	6.6	Coarse	3¼	225	8.9	Fine	1	76	26.3
	3	318	6.3	Coarse	3½	242	8.3	Fine	1	76	26.3
Limestone	1	108	18.5	.....	...	...	....	Fine	1½	108	18.5
	2	223	9.0	Interm	2¼	151	13.2	Fine	1	72	27.7
	2¼	240	8.3	Interm	2½	168	11.9	Fine	1	72	27.7
	2½	258	7.8	Coarse	2¾	186	10.8	Fine	1	72	27.7
	2¾	292	6.9	Coarse	3¼	220	9.1	Fine	1	72	27.7
	3	309	6.5	Coarse	3½	237	8.4	Fine	1	72	27.7

WEIGHT OF AGGREGATE

	Trap Rock		Limestone	
	Lb. Per Cu. Yd.	Lb. Per Sq. Yd. Per In. Depth Loose	Lb. Per Cu. Yd.	Lb. Per Sq. Yd. Per In. Depth Loose
Fine	2740	76	2600	72
Intermediate	2455	68	2425	72
Coarse	2490	69	2435	68

Specifications for Liquid Asphaltic Road Materials

From a pamphlet issued by The Asphalt Institute, 801 Second Ave., New York, and 206 Sansome St., San Francisco, in 1933.

The specifications for liquid asphaltic road materials presented in this pamphlet have been developed as the result of numerous conferences with representatives of the United States Bureau of Public Roads and the various state highway departments, and supersede former Specifications Nos. 1 to 7 inclusive of The Asphalt Institute. They have been prepared to conform with the simplified scheme of analysis developed at these conferences, and cover the great bulk of satisfactory products which are now being furnished by the producers for various classes of highway treatment and construction.

General adoption of the simplified form of specification by the users of liquid asphaltic road materials is to be greatly desired for the following reasons:

1. The simplified form reduces all specifications to a common language by means of which the various products can be correctly compared and evaluated.

2. It eliminates a large number of unnecessary tests heretofore commonly used, with their accompanying variations, and makes possible a clearer interchange of opinions and experiences among consumers and producers.

3. It prevents the unnecessary overlapping in grades of products which are to serve a single purpose, which overlapping has resulted from the variable forms of specifications developed by individual localities.

The simplified scheme embodies the following three fundamental determinations:

1. Determination, by means of a viscosity test, of the consistency or degree of fluidity of the original material at as near normal temperature as practicable, which indicates the suitability of the product from the standpoint of application, for a given type of treatment or method of construction.

2. Determination, by means of the distillation test, of the amount and character of lighter constituents which may be expected to eliminate themselves through volatilization or absorption during manipulation and early use, which indicates the probable rate of curing.

3. Determination, by means of the penetration or float test of the consistency of the residue from distillation, which indicates the probable extent of curing and the character of the product eventually retained by the mineral aggregate in the highway which has been treated.

In the following tabulated specifications, liquid asphaltic road materials have been grouped under three classifications: R.C., or rapid curing cut-back asphalts; M.C., or medium curing cut-back asphalts; and S.C., or slow curing products. Under each classification the individual specifications have been numbered consecutively as the viscosity of the products increases. Numerical values opposite the individual tests, when followed by a + sign, signify not less than the value shown and if followed by a — sign, not more than the value shown.

Following each set of tabulated specification requirements are descriptions of the type of treatment or construction for which materials under each individual specification are best suited. The table of Principal Uses summarizes these descriptions and illustrates the interrelationship of all of the products specified. Reference to standard tests and descriptions of tests not yet officially adopted as standard, which are embodied in these specifications, are given in conclusion.

Specifications for Type R. C. Materials

Specificaton Designation	RC–1	RC–2	RC–3	RC–4
General Requirement	The material shall be free from water and shall meet the following requirements when tested in accordance with the methods hereinafter enumerated.			
Flash Point (Open Tag.) ° F....	80+	80+	80+	80+
Furol Viscosity at 122° F.....	80–160	200–400	.....	.....
Furol Viscosity at 140° F.....	.....	.....	275–400	700–1400
Distillation, per cent by volume:				
Total Distillate to 374° F.....	5+	.....	.....	.....
Total Distillate to 437° F.....	12+	10+	3+	0.5+
Total Distillate to 600° F.....	25+	20+	14+	7+
Total Distillate to 680° F.....	40—	35—	30—	25—
Tests on Residue from Distillation:				
Penetration 77° F. 100 g., 5 sec.	60–120	60–120	60–120	60–120
Ductility at 77° F.....	60+	60+	60+	60+
Per cent Soluble in Carbon Disulphide	99.5+	99.5+	99.5+	99.5+

Type R.C.-1.—This specification provides for a rapid curing liquid product of low initial viscosity suitable for surface treatment and retreatment as seal coat, or in the construction of thin bituminous carpet courses with a light cover of suitable mineral aggregate free from dust.

Type R.C.-1 is not intended for use as a primer on untreated roads, as it is apt to harden before it can penetrate the surface. Before application to non-bituminous surfaces the road should preferably be primed with Type M.C.-1 Material.

Type R.C.-2.—This specification provides for a rapid curing liquid product of relatively low viscosity, suitable for the preparation of cold-patch mixtures, with open-graded mineral aggregate having little or no material passing the 10-mesh and practically none passing the 200-mesh sieve. If the asphaltic material is warmed prior to admixture with the mineral aggregate, suitable precautions should be taken to avoid fire hazard. The mixture should preferably be aged in stock piles for 24 hours or more before use.

This material may also be used in cool weather for the type of construction described under Type R.C.-3.

Type R.C.-3.—This specification provides for a rapid curing product of relatively high viscosity suitable for use in the construction of roller compacted road-mix wearing courses, or for cold-patch mixtures, in which the mineral aggregate is of the open type, consisting principally of crushed fragments, maximum size not over 1½ inches, and practically all of which is retained on a ¼ inch screen. The asphaltic material should be warmed prior to application with suitable precautions to avoid fire hazard. It is not intended for use with aggregate containing a high dust content.

Type R.C.-2 material may be used for this class of construction in cool weather, particularly in cases where the maximum diameter of mineral aggregate particle does not exceed 1 inch.

Type R.C.-4.—This specification provides for a rapid curing product of high viscosity suitable for use in the construction of roller compacted cold laid plant-mix wearing courses in which the mineral aggregate is of the open type, consisting principally of crushed fragments, maximum size not over 1½ inches and practically all of which is retained on a ¼ inch screen. It is particularly adapted for use under conditions where the mixture is to be laid and compacted immediately after mixing. The asphaltic material should be warmed prior to use with suitable precautions to avoid fire hazard.

Specifications for Type M. C. Materials

Specification Designation	MC-1	MC-2	MC-3	MC-4	MC-5
General Requirement	The material shall be free from water and shall meet the following requirements when tested in accordance with the methods hereinafter enumerated.				
Flash Point (Open Tag) ° F..	.....	150+	150+	150+	150+
Furol Viscosity at 77° F...	40–150	.....	.....	.....	.....
Furol Viscosity at 140° F...	.....	150–250	300–500	500–800	.....
Furol Viscosity at 180° F...	.....	.....	.....	.....	170–280
Distillation, per cent by volume:					
Total Distillate to 437° F.	10—	2—	2—	1—	1—
Total Distillate to 600° F.	25+	10–20	8–20	16—	14—
Total Distillate to 680° F.	50—	27—	25—	25—	20—
Tests on Residue from Distillation:					
Penetration 77° F., 100 g., 5 sec.	70–300	100–300	100–300	100–300	100–300
Ductility at 77° F.	60+	60+	60+	60+	60+
Per cent Soluble in Carbon Disulphide	99.5+	99.5+	99.5+	99.5+	99.5+

Type M.C.-1.—This specification provides for a liquid product of very low viscosity for cold application, suitable for use as a primer for initial surface treatment of road surfaces preparatory to the construction of a bituminous carpet or wearing course. It is readily and completely absorbed by earth, gravel or broken stone surfaces, where it hardens in place. While it develops considerable cementitiousness upon drying, it is not intended to hold a cover of stone chips or gravel.

Type M.C.-2.—This specification provides for a medium curing liquid product of low viscosity suitable for use in the construction of traffic compacted road-mix wearing courses in which the mineral aggregate is densely graded, from a maximum diameter of 1 inch down, with from 35 to 60 per cent of material passing a 10-mesh sieve and from 7 to 14 per cent passing a 200-mesh sieve. This material should ordinarily be warmed before application. Its viscosity increases materially after use so as to develop considerable cementitiousness. It is therefore adapted for the type of construction described, under severe climatic conditions. It does not, however, harden with sufficient rapidity to be used to best advantage as a binder for coarse open mineral aggregates free from dust.

Type M.C.-3.—This specification provides for a medium curing liquid product of medium viscosity suitable for use in the construction of traffic compacted cold laid plant-mix wearing courses in which the mineral aggregate is densely graded from a maximum of 1 inch down, with from 35 to 60 per cent of material passing a 10-mesh sieve, and from 7 to 14 per cent passing a 200-mesh sieve.

It is also suitable for use in the construction of roller compacted, road-mix wearing courses in which the mineral aggregate is of the open-graded type with a maximum diameter of not over 1 inch, containing little or no material passing the 200-mesh but having a relatively high percentage passing the 10-mesh sieve.

This material should be warmed before application. Its viscosity increases materially after use so as to develop considerable cementitiousness, and it is therefore adapted to both types of construction described, under severe climatic conditions.

Type M.C.-4.—This specification provides for a medium curing liquid product of relatively high viscosity suitable for use in the construction of roller-compacted, cold laid plant-mix wearing courses, or road wearing courses in hot weather, in which the mineral aggregate is of the open-graded type with a maximum diameter of 1 inch, containing little or no material passing the 200-mesh but having not less than 35 per cent passing the 10-mesh sieve. The asphaltic material, and sometimes the aggregate, requiring warming before mixing.

Type M.C.-5.—This specification provides for a medium curing product of high viscosity suitable for use in the construction of roller compacted, cold-laid plant-mix wearing courses, in which the mineral aggregate is of the open-graded type with a maximum diameter of 1 inch, containing practically no material passing the 200-mesh but having an appreciable percentage passing the ¼ inch screen. The asphaltic material and usually the aggregate require warming before mixing.

Specifications for Type S. C. Materials

Specification Designation	SC-1*	SC-2	SC-3	SC-4
General Requirement	The material shall meet the following requirements when tested in accordance with the methods hereinafter enumerated.			
Water and Sediment, per cent..	2—	2—	2—	2—
Flash Point (Cleveland Open Cup) Deg. Fahr.	150+	200+	200+	250+
Furol Viscosity at 77 Deg. F...	20–150	.....	.....	.....
Furol Viscosity at 122 Deg. F...	.....	200–300	.....	.....
Furol Viscosity at 140 Deg. F...	.....	.....	150–300	350–550
Distillation, per cent by volume:				
Total Distillate to 437 Deg. F.	.....	2—	2—	2—
Total Distillate to 600 Deg. F.	.....	15—	10—	8—
Total Distillate to 680 Deg. F.	50—	25—	20—	18—
Tests on Residue from Distillation:				
Float at 122 Deg. F.	50—	25+	25+	25+
Per cent Soluble in Carbon Disulphide	99.0+	99.0+	99.0+	99.0+

*Within the viscosity limits specified, the Pacific Coast Producers will, when required, furnish material with a maximum Furol Viscosity limit of 40 at 77 deg. F., formerly designated 30–40 Road Oil.

Type S.C.-1.—This specification provides for a product of very low viscosity suitable for cold applications as a dust layer. It may also be used for initial treatments in the progressive method of mat construction on soils or fine grained aggregates where gradual improvement is to extend over a number of years with subsequent treatments employing more viscous asphaltic road materials. This product is not intended to serve as a hardening or cementing medium.

Type S.C.-2.—This specification provides for a very slow curing liquid product of low viscosity suitable for use in dry climates during cool weather in the construction of traffic compacted road-mix wearing courses in which the mineral aggregate is densely graded, from a maximum diameter of 1 inch down, with from 35 to 60 per cent of material passing a 10-mesh sieve and from 7 to 14 per cent passing in a 200-mesh sieve. It could ordinarily be warmed before application. As it does not develop high cementitiousness, it cannot be expected to increase appreciably the stability of the aggregate.

This material may also be used in the blotter or mulch treatment of clay roads with a loose or floating cover of gravel aggregate.

Type S.C.-3.—This specification provides for a very slow curing liquid product of medium viscosity suitable for use in dry climates during hot weather, in the construction of traffic-compacted road-mix wearing courses in which the mineral aggregate is densely graded from a maximum diameter of 1 inch down, with from 35 to 60 per cent of material passing a 10-mesh sieve and up to 14 per cent passing a 200-mesh sieve. It requires warming before application. As this type of material does not develop high cementitiousness, it cannot be expected to increase appreciably the stability of the aggregate.

Type S.C.-4.—This specification provides for a very slow curing liquid product of relatively high viscosity, suitable for use in dry climates in the construction of cold-laid traffic-compacted plant-mix wearing courses in which the mineral aggregate is densely graded from a maximum diameter of 1 inch down, with from 35 to 60 per cent of material passing a 10-mesh sieve and from 7 to 14 per cent passing a 200-mesh sieve. The asphaltic material, and sometimes the aggregate, require heating before mixing. As this material does not develop high cementitiousness, it cannot be expected to increase appreciably the stability of the aggregate.

Liquid Asphaltic Road Materials

Principal Uses of Materials Meeting Specifications Recommended by the Asphalt Institute

Specification Designation. USE	R. C. (Rapid Curing) 1	2	3	4	M. C. (Medium Curing) 1	2	3	4	5	S. C. (Slow Curing) 1	2	3	4
Dust Layer	..	..	..	..	..	..	..	..	..	×	..	..	..
Primer	..	..	..	..	×	..	..	..	..	..	..	..	..
Seal, thin carpet coat with mineral cover	×	..	..	..	..	..	..	..	..	..	..	..	..
Blotter or Mulch Treatment	..	..	..	..	..	..	..	..	..	..	×	..	..
Cold Patch	..	×	..	..	..	..	..	..	..	..	..	..	..
Road Mix, Macadam Aggregate	..	..	×	..	..	..	..	..	..	..	..	..	..
Cold Laid Plant Mix, Macadam Aggregate	..	..	..	×	..	..	..	..	..	..	..	..	..
Road Mix, Dense graded agg., max. dia. 1", traffic compacted:													
Dry climate, cool weather	..	..	..	..	..	..	..	..	..	..	×	..	..
Dry Climate, hot weather	..	..	..	..	..	..	..	..	..	..	..	×	..
Severe climate	..	..	..	..	..	×	..	..	..	..	..	..	..
Road Mix, Open graded agg., roller compacted, max. diam. 1", high per cent pass. 10 mesh, low per cent 200 mesh	..	..	..	..	..	..	×	..	..	..	..	..	..
Cold Laid Plant Mix, Dense graded agg., max. diam. 1", traffic compacted:													
Dry climate	..	..	..	..	..	..	..	..	..	..	..	..	×
Severe climate	..	..	..	..	..	..	×	..	..	..	..	..	..
Cold Laid Plant Mix, Open graded agg., roller compacted, max. diam. 1", high per cent pass. 10 mesh, low per cent 200 mesh	..	..	..	..	..	..	..	×	..	..	..	..	..
Cold Laid Plant Mix, Open graded agg., roller compacted, max. diam. 1", high per cent pass. ¼" no 200 mesh	..	..	..	..	..	..	..	..	×	..	..	..	..

METHODS OF TEST

Flash Point (Open Tag)

(Method Approved by the Bureau of Explosives.)

The Tagliabue open cup flash tester shall be used.

The instrument shall set firm and level.

Fill the metal bath cup with water at a temperature of at least 20 degrees F. below the probable flash point of the oil to be tested, leaving room for displacement by the glass oil cup, which is then placed in the bath.

Fill the glass oil cup with the oil to be tested to within ⅛ inch of its upper level edge. See that there is no oil on the outside of the cup, or upon its upper level edge, using soft paper to clean the cup.

Adjust the horizontal flashing-taper guide-wire in place. Suspend the thermometer, with its bulb well covered by the oil. Heat bath with small flame lamp having the flame so adjusted that it will raise the temperature of the oil at a rate of 2½ degrees F. per minute, without removing the lamp during the whole operation.

For viscous liquids it is necessary that the liquid be stirred at intervals during the test.

Remove air bubbles, if any, from the surface of the oil before first trial for flash is made.

At the proper trial temperatures, noted below, try for flash with a small (not over ⅛ inch) bead of flame by drawing it quickly and without pause across the guide wire from left to right.

The temperature at which the first or initial flash is obtained is called the flash point.

Trial temperatures: For materials which may be expected to flash at about 80° F. try for flash first at 70° F., then at 75°, 77°, 79°, 81°, 83°, and 85°. For other materials try for flash first at a temperature about 20° F. below the expected flash point and then try for flash at every 5° F.

* * *

Flash Point (Cleveland Open Cup)

American Society for Testing Materials,—Standard Method D92-24.

* * *

Furol Viscosity (Saybolt Furol)

American Society for Testing Materials,—Standard Method D88-30.

Distillation

American Society for Testing Materials,—Standard Method D20-30, with the following exceptions:

Sample distilled shall be 200 cubic centimeters, the weight of this volume to be calculated from the specific gravity at 60° F.

Bulb of thermometer shall be immersed to a point one-fourth inch above bottom of flask.

Condenser shall be water cooled.

Distillate shall be collected in 100-cubic-centimeter graduated glass cylinders and the amount of distillate shall be reported in percentages by volume of water-free material.

Distillation shall be stopped at 680° F. and the total residue shall be poured immediately into an 8-ounce tin and allowed to air cool without covering to a temperature below its fuming point suitable for pouring. It shall then be stirred and poured into proper receptacles for additional tests. The amount of distillate shall be read to the nearest cubic centimeter after the condenser has been allowed to drain thoroughly into the receiver.

Temperatures observed in the distillation test shall be corrected for the effect of the altitude of the laboratory in which the test is made. (See A.S.T.M. standard method D86-30.)

* * *

Float Test

American Society for Testing Materials,—Standard Method D139-27.

* * *

Penetration Test

American Society for Testing Materials,—Standard Method D5-25.

* * *

Ductility Test

American Society for Testing Materials,—Tentative Standard Method D113-32T.

* * *

Solubility in Carbon Disulphide

American Society for Testing Materials,—Standard Method D4-27.

* * *

Water and Sediment

American Society for Testing Materials,—Standard Method D96-30.

Tar Surface Treatment

The State of Connecticut successfully treats many miles of gravel roads using cold tar. It is applied in small quantities, usually not more than 1/6 or 1/8 gallon per square yard on re-treatments and immediately covered with coarse sand or fine gravel. Ample cover is used so that traffic will not pick up the tar. The cover is dragged with a sled drag which accomplishes two things: the road surface is made much smoother since the drag cuts off the high spots and fills in the low ones; and the tar and covering material is thoroughly mixed so that the drying time is greatly reduced.—*From an article by George E. Martin in Roads and Streets.*

Bituminous Macadam Surface Course

Specifications, Massachusetts Department of Public Works

Description.—The bituminous macadam surface shall be laid on a broken stone base course constructed as hereinbefore specified.

The surface course shall be composed of broken stone and bituminous material applied by the penetration method with the bituminous material covered with pea stone.

The width and depth (after rolling) of the bituminous macadam surface course shall be as shown on the plans.

Materials.—The broken stone for the surface course shall consist of clean crushed rock having a percentage of wear of not more than 3 (French coefficient of wear of not less than 14) and a toughness of not less than twelve (12) unless otherwise specified in the Special Provisions. The stone shall be thoroughly screened, uniformly graded in size and quality, angular and free from rounded surface, and no flat, elongated or otherwise objectionable stone shall be used.

Stone used shall consist of No. 1 stone, excepting that pea stone shall be used for covering the bituminous material.

Pea stone shall be free from dust and shall conform to Section 32. [See "Broken Stone Base Course"—Materials.]

The bituminous material shall consist of asphalt or refined tar, as specified in the Special Provisions.

Oil asphalt shall meet the following requirements (Dept. Spec. No. 5):

1. It shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.)
2. Specific gravity 25° C. (77° F.)..not less than 1.000
3. Flash point.....not less than 175° C. (347° F.)
4. Penetration at 25° C. (77° F.) 100 g., 5 sec.85 to 100
5. Loss at 163° C. (325° F.) 5 hrs.not more than 1.0%
   a. Penetration of residue at 25° C. (77° F.) .....not less than 60%
6. Total bitumen (soluble in carbon disulphide) .....not less than 99.5%
7. Ductility 25° C. (77° F.).....not less than 60 cm.

Exception for oil asphalt applied from October 1 to April 30.

4. Penetration at 25° C. (77° F.) 100 g., 5 sec.100 to 120

Fluxed native lake asphalt shall meet the following requirements (Dept. Spec. No. 8):

1. It shall be homogeneous, free from water, and shall not foam when heated to 175° C. (347° F.).
2. Specific gravity 25° C. (77° F.).....1.025 to 1.050
3. Flash point.....not less than 175° C. (347° F.)
4. Loss at 163° C. (325° F.), 5 hrs.not more than 3.0%
   a. Penetration of residue at 25° C. (77° F.) .....not less than 50%
5. Penetration at 25° C.(77° F.), 100 g., 5 sec.120 to 150
6. Total bitumen (soluble in carbon disulphide) .....not less than 94.5%
   a. Inorganic matter insoluble.....2.0% to 3.5%
7. Ductility at 25° C. (77° F.)....not less than 60 cm.

Refined tar shall conform to the following requirements (Dept. Spec. No. 16):

1. It shall be homogeneous and free from water
2. Specific gravity 25/25° C. (77/77° F.) .....not less than 1.16
3. Float test at 50° C. sec.
   For Light Binder.....100 to160
   For Heavy Binder.....160 to 220
4. Total bitumen (soluble in carbon disulphide) .....not less than 75
5. Total distillate by weight (water free):
   To 170° C.....not more than 1.0
   To 270° C.....not more than 10.0
   To 300° C.....not more than 20.0
   a. Softening point of residue from distillation test °C.....45 to 70

Construction Methods.—Shoulders shall be relined and graded before the surfacing course is spread, in order to hold the broken stone in place and to permit the roller to lap at least one-half the width of a rear wheel when rolling the edge of the top course. A course of No. 1 stone shall then be spread upon the broken stone base course to a depth which after rolling will be that specified in the Special Provisions.

The rolling shall be done by a steam or other self-propelled three wheel roller weighing not less than twelve (12) tons, and the resulting pressure under the rear wheels shall be not less than five hundred (500) pounds per inch width of wheel.

All broken stone shall be spread from vehicles by hand, or from a dumping board, or from self-spreading vehicles which shall be of an approved type. If dumped on the base course in piles, it must not be deposited within the area over which it is to be spread. The course shall be shaped to a true section conforming to the proposed cross section of the highway, and when thoroughly rolled, shall conform to the proposed grade and cross section. Any depressions or irregularities which may occur shall be filled with broken stone as directed, and again rolled until the surface is true and unyielding. Before rolling, the wheels of the roller shall be cleaned and precautions taken to prevent the depositing of dirt or other material in the voids of the broken stone. The rolling shall then proceed as for the base course, care being taken in rolling the edges to overlap the shoulders by at least one-half the width of a rear wheel. Before any bituminous material is applied, all foreign substances and any unsuitable broken stone or broken stone which has become coated or mixed with dirt or foreign substances, shall be removed and replaced with clean No. 1 stone. The stone shall be perfectly dry before the bituminous material is applied.

The bituminous material shall be uniformly applied upon the upper course of stone prepared as specified above by an approved pressure distributor equipped with pneumatic tires capable of spraying successfully, if required, for a width of not less than fifteen (15) feet, at a pressure between forty (40) and sixty (60) pounds per square inch.

The rate of application shall be two (2) gallons per square yard of surface unless otherwise specified in the Special Provisions. The surface shall then be covered with sufficient clean pea stone to keep the bituminous materials from sticking to the wheels, care being taken that the rolling starts while the surface is still warm. The pea stone shall be added in small amounts while the rolling continues. Brooms shall be used in distributing the pea stone, and only a quantity sufficient for filling the voids shall be spread, and any excess shall be avoided. Before rolling proceeds, any surplus bituminous material on the shoulders shall be removed in order to permit rolling the shoulders in conjunction with the surface. Immediately before the seal coat is applied, the surface

shall be thoroughly swept to remove all loose material and dust. The seal coat shall then be evenly applied in the same manner as the penetration coat and at the rate of three-eighths (⅜) of a gallon per square yard and immediately covered with pea stone

Bituminous material when applied to the upper course of stone shall have a temperature of not less than 300° F. nor more than 350° F. for asphalt, and not less than 200° F. nor more than 275° F. for tar. The contractor shall not allow the bituminous material to be overheated or burnt.

After the seal coat is applied, any surplus bituminous material on the shoulders shall be removed, in order to permit them to be rolled with the finished surface.

Tank wagons and trucks used for the transportation or application of asphalt shall be equipped with satisfactory thermometers for measuring the temperature of the material to be applied, and shall have either a steam or air-kerosene system for the clearing of lines and pumps. Deliveries will be refused when trucks or wagons are not so equipped. Evidence of fluxing with kerosene or emulsification by steam will be sufficient cause for rejection of the delivery.

When spraying bituminous material, the contractor shall cover concrete walks, curbs, walls and adjacent surface along the roadway with paper or other satisfactory covering, and shall remove any bitumen which adheres to this concrete. No additional compensation will be allowed the contractor for this work.

After the final rolling, the surface shall be tested with a ten (10) foot straight edge and, before acceptance, any depressions or irregularities of three-eights (⅜) of an inch or greater shall be satisfactorily eliminated by rolling or by replacing the surface so that the final surface will be perfectly uniform and true to the specified cross section and grade.

If at any time before the work is accepted by the Department any soft or imperfect places or spots shall develop in the surface, all such places shall be removed and replaced with new material and then rolled until thoroughly compacted and until the joints or edges at which the new work connects with the old become invisible. All such removal and replacing of unsatisfactory surfacing shall be done at the expense of the contractor.

No bituminous work shall be done during rainy weather nor when weather conditions as to temperature or otherwise are unsatisfactory for obtaining good results.

The stone shall be weighed and the weight computed as provided for under Sections 25 and 26. [Not quoted here.]

Asphalt delivered in tank truck distributors or tank truck feeders from refineries or distributing plants shall be weighed on scales furnished by and at the expense of the contractor. Said scales shall be sealed at the expense of the contractor as often as is necessary to insure their accuracy. At the option of the Department a sworn weigher to be appointed and compensated by the Department shall weigh all asphalt required to be weighed.

Basis of Payment.—This work will be paid for as follows:

The broken stone will be paid for at the contract unit price per ton of broken stone, complete in place. The bituminous material will be paid for at the contract unit price per gallon of bituminous material, complete in place. For the purpose of measurement, a gallon shall be a volume of 231 cubic inches and measurement shall be based on the volume of the bituminous material at its temperature when applied.

Asphalt and tar delivered from refineries and distributing plants in tank truck distributors and tank truck feeders shall be weighed and the volume shall be computed on the basis of weight as follows:

a. Weight of asphalt at 350° F. = 7.7 lbs. per gallon.
b. Weight of tar at 275° F. = 9.5 lbs. per gallon.

Asphalt and tar delivered in tank cars when not actually weighed shall be measured by volume at the loading temperature and the quantity converted to the applying temperature on the basis of a coefficient of expansion or contraction per degree F. of .00036 for asphalt and .0003 for tar. In no case shall the total number of gallons of bituminous material for any car be in excess of the U. S. Interstate Commerce Commission's rating for the car plus or minus expansion or contraction based on the volumetric change between the loading and the specific maximum applying temperature.

The above prices shall include all materials, equipment, tools, labor and work incidental thereto.

Approximate Quantities of Materials Required for Asphalt Wearing Courses and Foundations

From Pocket Reference for Engineers of The Asphalt Association

Sheet Asphalt

Binder 1½ In. Thick, Wearing Course 1½ In. Thick

Materials	Pounds Per Sq. Yd.	Tons Per Mile I Ft. Wide
Binder Stone	116	34.0
Sand—		
Top	115	33.8
Binder	45	13.2
Mineral Filler	22	6.5
Asphalt—		
Top	16	4.7
Binder	9	2.6

Asphalt Macadam Base

6 In. Thick

Materials	Pounds Per Sq. Yd.	Tons Per Mile I Ft. Wide
Coarse Stone	545	159.8
Intermediate Stone (Optional)	45	18.2
Asphalt	22	6.5

Asphaltic Concrete Base

3 In. Thick

Materials	Pounds Per Sq. Yd.	Tons Per Mile I Ft. Wide
Coarse Stone	216	63.4
Sand	100	29.3
Asphalt	18	5.3

Asphalt Macadam Wearing Course

2½ In. Thick

Materials	Pounds Per Sq. Yd.	Tons Per Mile I Ft. Wide
Coarse Stone	227	66.6
Intermediate Stone	45	13.2
Fine Stone	25	7.3
Asphalt	19	5.6

Fine Graded Aggregate Asphaltic Concrete

2 In. Thick

Materials	Pounds Per Sq. Yd.	Tons Per Mile I Ft. Wide
Stone Chips	53	15.5
Sand	123	86.1
Mineral Filler	18	5.3
Asphalt	18	5.3

Coarse Graded Aggregate Asphaltic Concrete

2 In. Thick, Excluding Seal Coat

Materials	Pounds Per Sq. Yd.	Tons Per Mile 1 Ft. Wide
Coarse Stone	147	43.1
Sand	58	17.0
Mineral Filler	9	2.6
Seal Coat Stone	25	7.3
Asphalt	18	5.3

Amounts of Materials for Penetration Bituminous Macadam.—Wilson G. Harger in his "Rural Highway Pavements," gives the following:

"For penetration top course our records in western New York show that the proportion of sizes per cubic yard of finished top (limestone aggregate) are approximately as follows:

	Per cent
1½ to 2½ in. size crushed stone	65
¾ to 1½ in. size	20
Dustless screenings	15

The total weight of all sizes limestone specific gravity 2.7 (170 lb. per cubic foot solid) is about 4,250 lb. per cubic yard for a 2½ in. consolidated depth of finished macadam and about 4,350 lb. per cubic yard for a 3 in. consolidated depth.

The following table is from the Asphalt Association:

Asphaltic Macadam Wearing Course
(2½ in. Consolidated Thickness)

Materials	Lbs. per sq. yd.
Coarse stone	227
Intermediate stone	45
Screenings	25
Asphalt	19
Total	316

For single coat work on steep grades, 1.5 gal. per square yard applied in one coat is satisfactory for 2½ in. depth of top and 1.75 gal. per square yard for the 3 in. depth. When seal coats are used on the lighter grades 0.4 to 0.5 gal. is generally used.

Weights of Asphalt Paving and Road Material.—Asphalt of a specific gravity of 1.0 or unity weighs 8.33 lb. to the gallon or 62.5 lb. to the cubic foot. The following table from a handbook of the Asphalt Association shows the weight in pounds per gallon for various specific gravities:

Sp. Gr.	Weight	Sp. Gr.	Weight
1.00	8.33	1.04	8.66
1.01	8.41	1.05	8.75
1.02	8.50	1.06	8.83
1.03	8.58		

A handbook of the Standard Oil Company of Indiana gives the following:

Paving asphalt weighs 8.5 lb. to the gallon, approximately 235 gal. to the ton at 60° F.

One cu. ft. of paving asphalt weighs 64 to 65 lb.

One ton of paving asphalt contains approximately 30 cu. ft.

One drum of paving asphalt contains 48 to 50 gal.

One drum of asphalt weighs approximately 440 lb.

The weight of standard sheet asphalt 2 in. thick, rolled and compressed on a uniform close binder, is 200 lb. to the square yard.

The weight of close binder 1½ in. thick, rolled and compressed on uniform concrete base, is 130 to 140 lb. to the sq. yd.

The weight of asphaltic concrete 2 in. thick, rolled and compressed on uniform concrete base, is 200 to 210 lb. to the sq. yd.

The weight of asphalt macadam 2½ in. thick, rolled and compacted, is 250 to 260 lb. to the sq. yd.

Costs of Bituminous Surface Course Construction in New Mexico

From Low Cost Roads and Bridges, by Victor J. Brown and Carleton N. Connor

Completed to Sept. 1, 1930

Length in Miles	Cross Section of Mat	Moving to Job Cost Per Mi.	Scarifying Cost Per Mi.	Harrowing Cost Per Mi.	Heating Oil Cost Per Mi.	Distributing Oil Cost Per Mi.	Processing Cost Per Mi.	Laying Down & Spreading Cost Per Mi.	Shaping & Finishing Cost Per Mi.	Equipment Rental Cost Per Mi.	Total Mixing Cost Per Mi.	Working Days Per Mi.†	Oil Cost Per Mi.	Cost Per Mi. Including Testing	Cost of Metal Per Mi.	All Other Costs Per Mi.	Grand Total Cost Per Mi.
11.2	18'x3"	.....	$61.73	$ 34.25	$ 47.27	$184.27	$128.26	.....	$ 34.37	$128.57	$ 618.71	3.57	$ 816.64	$1,457.31	$1,480.16	$ 0.00	$2,937.47
2.0	18'x4"	.....	0.00	75.13	3.06	209.89	155.26	.....	68.99	126.00	648.33	3.00	1,181.62	1,841.22	762.00	0.00	2,603.22
11.5	18'x3"	$ 60.83	44.78	84.35	57.34	225.85	131.08	.....	68.49	166.91	839.63	3.57	580.86‡	1,424.89	1,072.62	66.04	‡2,563.55
16.1	18'x3"	88.88	88.94	84.87	25.00	196.03	112.98	$ 20.79	27.84	89.44	608.31	1.93	961.81	1,620.00	1,736.23	0.00	3,356.23
10.5	18'x4"	99.02	12.86	90.20	21.12	253.71	117.35	26.96	41 08	124.28	787.17	2.38	1,164.62	1,975.78	1,637.19	106.57	3,719.54
15.9	20'x4"	81.73	35.80	101.93	53.43	257.99	54.33	35.97	39.30	173.90	832.93	3.02	958.92	1,815.63	1,131.70	249.63	3,196.96
20.2	20'x3¼"	20.28	76.56	178.73	60.83	289.58	169.04	46.17	51.07	225.60	1,117.33	3.71	1,153.86	2,298.22	1,792.63	179.21	4,270.06
13.2	20'x3½"	10.44	8.33	131.08	59.62	309.28	293.14	58.12	42.36	177.32	1,090.43	3.41	1,175.48	2,287.82	1,123.72	207.48	3,619.02
11.9	20'x3½"	0.00	16.45	107.84	27.68	272.29	234.13	23.95	53 15	126.05	860.56	2.94	1,118.24	2,001.03	888.37	390.87	3,280.27
8.0	20'x3½"	24.41	24.11	85.12	65.73	395.31	533.88	31.36	88 97	280.00	1,584.21	7.00	1,659.73	3,284.81	1,022.56	140.05	4,447.42
4.8	20'x3½"	0.00	7.00	58.56	36.54	60.58	235.67	30.09	124.02	229.92	764.86	4.79	1,139.75	1,930.86	1,691.83	355.08	3,977.77
13.3	20'x3"	6.42	16.71	76.72	85.41	59.81	217.04	14.01	123 68	229.65	782.03	3.68	1,311.63	2,120.50	2,340.86	429.08	4,890.44
9.3	20'x3"	57.05	31.10	183.40	91.37	116.72	433.88	62.63	124 61	273.99	1,374.76	7.31	1,132.12	2,529.45	1,831.01	326.77	4,687.23
14.4	20'x3"	51.79	7.35	94.27	71.63	105.32	235.11	14.66	93 53	311.61	985.30	6.18	1,212.09	2,234.89	1,631.87	0.00	3,866.76
3.0	20'x3"	79.73	99.28	78.57	48.27	56.10	229.24	71.85	90 99	239.65	993.69	4.33	1,015.02	2,046.04	1,684.74	3,108.90	6,839.68
4.9	20'x3"	0.00	26.87	112.13	85.15	403.79	227.96	22.92	52 96	85.57	1,116.14	3.67	1,258.49	2,401.87	2,084.52	201.41	4,687.80
7.6	20'x3"	0.00	52.92	134.49	83.56	318.78	318.78	36.51	119 82	178.95	1,244.12	4.74	1,084.08	2,350.31	1,858.25	74.77	4,355.33
1.3	20'x3"	0.00	0.00	151.59	125.65	270.19	565.26	99.42	180 48	261.54	1,669.52	8.46	1,198.06	2,898.35	1,745.92	295.84	4,940.11
17.0	20'x3"	9.05	65.52	148.90	106.01	86.38	314.27	48.82	98 85	283.22	1,158.02	5.18	904.42	2,086.40	2,265.31	256.65	4,608.36
11.1	20'x3"	0.00	19.43	142.78	52.56	76.47	206.48	35.91	69 01	396.35	998.82	4.91	1,288.04	2,324.29	1,528.43	135.29	3,988.01
2.0	24'x3½"	0.00	0.00	103.82	113.57	133.93	283.41	23.84	82.07	189.83	927.47	6.48	1,583.32	2,565.54	866.94	0.00	3,432.48
3.4	20'x3"	0.00	0.00	92.34	120.06	113.25	232.27	20.20	62 74	227.54	868.40	6.48	942.61	1,857.33	1,473.79	0.00	3,331.12
21.6	20'x2½"	118.97	35.95	102.19	40.53	110.98	246.39	24.63	92.25	263.26	1,032.62	4.17	1,063.31	2,122.27	1,375.53	26.20	3,524.00
7.7	20'x2½"	84.27	23.43	75.96	23.63	294.19	152.68	26.24	62.63	128.41	871.44	3.72	1,025.70	1,929.29	1,082.56	35.92	3,047.72
14.1	20'x3"	0.00	0.00	79.18	88.51	96.96	189.40	14.23	42.20	227.30	737.78	2.55	1,002.94	1,752.03	2,061.12	266.86	4,080.01
2.9	20'x3"	118.05	0.00	106.80	65.66	281.60	277.46	13.07	51.47	199.83	1,113.93	9.31	966.25	2,112.94	1,412.47	337.29	3,862.70
2.7	20'x3"	15.59	56.02	122.63	54.48	345.95	366.25	23.71	42 93	222.74	1,250.30	4.44	1,170.49	2,507.83	1,257.30	162.34	3,927.47
10.8	22'x3"	141.42	0.00	88.10	63.60	112.14	299.60	27.31	59.65	289.06	1,060.86	3.80	1,358.89	2,399.10	1,202.92	58.37	3,660.39
9.8	20'x3"	7.32	20.32	70.95	32.89	303.44	235.69	12.71	86 00	151.37	920.69	2.96	1,217.09	2,137.76	1,233.09	81.50	3,452.35
0.19	20'x3"	0.00	0.00	84.47	46.08	59.47	214.05	60.79	122 11	390.26	977.21	5.00	1,630.26	2,607.47	1,396.84	82.16	4,086.47
1.6	20'x3"	0.00	0.00	204.13	42.97	122.50	330.46	120.21	113 75	499.38	1,433.39	6.25	1,280.06	2,742.26	1,694.78	247.57	4,684.61
9.0	20'x3"	89.97	37.10	56.03	87.92	142.42	419.38	27.32	112 87	357.47	1,330.47	4.67	1,276.34	2,605.81	1,070.77	0.00	3,676.58
4.5	20'x3½"	0.00	0.00	158.50	121.34	153.10	194.85	73.78	99.62	216.71	1,017.89	5.33	1,447.03	2,498.26	3,720.53	0.00	6,218.79
3.2	20'x3"	0.00	51.93	55.48	44.29	167.33	501.00	20.86	98.28	358.78	1,297.94	5.16	1,573.32	2,932.20	1,463.85	0.00	4,396.05
14.7	20'x3"	3.28	0.00	140.15	68.92	81.92	304.92	55.24	103.63	369.69	1,127.77	5.51	1,257.09	2,392.00	1,978.48	3,151.52	7,522.00
8.9	20'x3"	79.40	0.00	117.11	127.25	287.00	226.13	80.22	90.57	182.36	1,190.06	3.83	1,595.16	2,817.91	1,403.40	0.00	4,221.31
6.2	20'x3"	56.54	0.00	153.87	111.79	336.01	232.16	85.43	159.72	271.82	1,407.35	5.00	1,780.60	3,215.49	1,119.32	0.00	4,334.81
0.64	20'x3"	0.00	45.00	256.44	208.39	53.17	491.44	184.89	274.59	302.49	1,815.94	4.70	1,603.86	3,465.10	1,124.05	0.00	4,589.16
0:38	20'x3"	0.00	42.00	240.00	224.13	105.32	453.63	171.00	187.61	212.26	1,635.95	5.26	1,848.84	3,564.74	1,492.44	0.00	5,057.18
2.5	20'x3"	310.11	0.00	178.12	117.80	144.80	747.49	39.94	121.92	796.36	2,456.58	5.20	1,391.42	3,847.97	2,445.81	0.00	6,293.78
3.5	20'x3"	0.00	0.43	277.51	80.61	320.77	401.50	95.39	204.77	347.31	1,728.28	6.86	1,816.81	3,591.37	1,530.06	0.00	5,122.06
411.13		44.58	26.50	113.09	64.83	189.66	248.07	36.24	83.13	232.29	1,038.39	4.57	1,134.72	2,197.44	1,622.87	297.55	4,117.86

NOTES: †Does not include time moving to job.
‡Gov't Freight rates on oil accounts for low cost this job.

Coarse Aggregate Pavement Using Emulsified Asphalt

The data and recommendation here given for the construction of coarse aggregate pavement using emulsified asphalt are from *Low Cost Roads and Bridges* by Victor J. Brown and Carleton N. Conner.

The purpose of this discussion, which was written by Mr. C. L. McKesson, is to describe construction methods where emulsified asphalt is used. Using asphalt emulsions, both graded aggregate (Type-A) and coarse aggregate types have been successful, and the relative stability of either type depends entirely on local conditions and percentage of dust in the aggregate. This discussion will be confined entirely to the coarse aggregate type.

Thickness.—The thickness should depend largely on the character of the base. Where the base consists of an old road, previously treated and not too irregular in surface, a coarse aggregate type having a finished thickness of 1¼ in. to 1½ in. seems to be most economical. Where the base consists of untreated gravel, or other metal not well compacted, or where the base requires considerable re-shaping prior to the construction of the surface, engineers generally seem to favor a finished thickness of 2 in. for the surface. Thicknesses less than 1¼ in. should usually be preceded by a tack coat, or primer, the quantity of primer depending upon the condition of the surface, ⅛ gallon per square yard usually being sufficient on bituminous treated work, and ¼ to ⅓ gallon on untreated bases.

Aggregate.—In emulsified asphalt construction the same considerations apply regarding quality of aggregate as when other binders are used. It is, however, questionable whether lines should be too tightly drawn as to percentage of wear, shape of particles, uniformity, etc. The coarse aggregate type of work, to be economical, should utilize locally available and inexpensive material whenever possible. Properly bituminizing even the softer aggregate by coating with asphalt during the process of construction tends to protect it from weathering and abrasion under traffic. If properly constructed, the surface is also protected by a bituminous seal coat. Serious consideration should, therefore, be given before otherwise suitable aggregate is rejected because it does not conform with usually recognized standards as to quality or hardness. Low cost road work necessitates every possible economy in selection of aggregates, as well as in selection of type. Softer aggregates require the maximum quantity of emulsion shown in the Table of Materials. Rounded materials also require more binder than angular materials, because they do not bond and lock together as readily.

Emulsified Asphalt.—Two types of emulsified asphalt are required for this construction work. The first application on the coarse aggregate necessitates the use of an emulsion which is sufficiently slow-setting to permit of mixing and coating before the asphalt coalesces. This mixing emulsion may also be used in a diluted form for tack coat or priming.

The first and second penetration applications require the use of a quick-setting emulsion, of a viscosity which will insure proper penetration and coating.

Emulsions differ widely in their characteristics, and in order to secure proper results it is always necessary that an emulsion be selected which has suitable properties for the work in hand. In order to be certain of good construction, emulsions for use in this work should meet the following requirements:

	Slow-Setting Mixing Emulsion	Quick-Setting Penetration Emulsion
Specific Gravity 25°/25° C. (77°/77° F.)—Not less than	1.01	1.01
Miscibility—Separation 2 hrs.	None	...*
Coating—Separation ASTM coating test.	None	...†
Residue at 163° C. (325° F.) 3 hrs. 200 gms.—Not less than	55%	55%
Demulsibility—50 cc. N/10 $CaCl_2$—Not more than	20%	...
Demulsibility—35 cc. N/50 $CaCl_2$—Not less than	...	60%
Distillation by Weight:		
Oil distillate to 260° C. (500° F.)—Not more than	2%	2%
Residue at 260° C. (500° F.)—Not less than	55%	55%
Penetration Residue at 25° C. (77° F.)	100 to 200	100 to 200
Solubility in carbon disulphide—Not less than	98%	98%
Ash—Not more than	1.25%	1.25%

*No requirement.
†Coating undesirable.

Construction.—The construction operations as outlined heretofore for Road-Mix, Coarse Aggregate Type, could be followed without change where emulsified asphalt is used as binder. However, due to the extreme fluidity of emulsion and its tendency toward ready coating of stone, modifications in construction methods are recommended.

Table of Materials

(Quantities Are Per Square Yard)

(Compacted) Finished Thickness (Inches)	Coarse Rock Size in In.	Coarse Rock Lb.	First Appl. Mixing Emulsion (Gals.)	Keyrock* ¾ In. ¼ In. (Lb.)	Second Appl. Penet. Emulsion (Gals.)	Rock Chips* ⅜ to 10 Mesh (Lb.)	Third Appl. Penet. Emulsion (Gals.)	Sand or Rock Chips* ⅛ In.-10 Mesh (Lb.)	Total Rock Lb.	Total Rock Cu. Yd.	Total Emulsion (Gals.)
2½	2½	200	0.6	25	0.5	12	0.4	8	245	.096	1.9
	to	to	to	to	to	to	to	to	to	to	to
	½	210	0.8	30	0.7	18	0.6	12	260	.102	2.1
2	2	140	0.5	20	0.5	12	0.4	8	190	.075	1.7
	to	to	to	to	to	to	to	to	to	to	to
	½	160	0.7	25	0.7	18	0.6	12	210	0.83	1.9
1½	1½	110	0.4	15	0.5	12	0.4	8	145	.057	1.4
	to	to	to	to	to	to	to	to	to	to	to
	½	125	0.5	20	0.6	18	0.6	12	170	.067	1.6
1¼	1	100	0.4	10	0.4	10	0.3	8	125	.049	1.2
	to	to	to	to	to	to	to	to	to	to	to
	½	115	0.5	20	0.5	15	0.5	12	150	.059	1.5

(Assumed weight of aggregate 2,550 lb. per cubic yard.)
*Sizes indicated refer to standard A. S. T. M. circular opening screens and 10 mesh sieves.
Not more than 10 per cent of the material shall be either coarser or finer than maximum and minimum sizes indicated.

With emulsified asphalt the stages of construction are usually as follows:

1. Prepare foundation.
2. Apply prime coat (if needed).
3. Spread and level coarse aggregate.
4. Apply coat of asphaltic mixing emulsion.
5. Mix, by turning stone *once* or *twice* with suitable equipment.
6. Shape aggregate to proper cross-section.
7. Roll lightly.
8. Spread key-stone, and broom-drag to secure uniform distribution.
9. Roll and broom.
10. Apply quick-setting penetration asphaltic emulsion.
11. Spread stone chips; broom-drag and roll.
12. Apply final application quick-setting asphaltic emulsion.
13. Spread fine stone chips, or coarse sand.
14. Roll to finished surface.

In comparing this schedule of operations with the one contained in the previous section, it will be found that the method here described includes only one mixing application and two penetration applications of emulsified asphalt. The use of two mixing applications and one penetration application, as recommended hereinbefore for tars and cut-backs, has been followed, using emulsion as the binder, but appreciably better results are obtained by substituting for the second mixing coat an application of penetration emulsion. The elimination of the second mixing operation effects an appreciable saving in cost and in time, while even better coverage of aggregate is secured by the additional penetration application. The use of two sizes of cover stone—one designated as "key-stone" and the other as "stone chips," is distinctly advantageous, tending to produce a more tightly keyed and bound waterproof pavement, also to produce increased smoothness and improved riding properties.

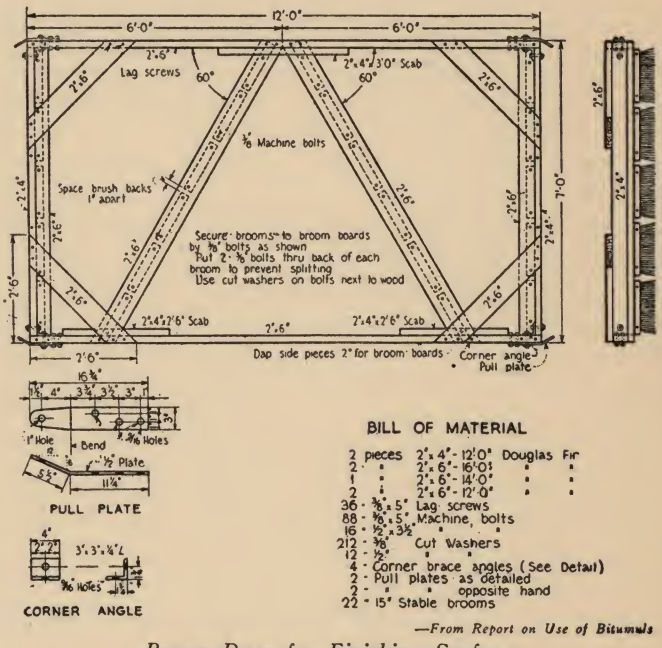
Preparation of Foundation.—Proper patching and reconstruction of the existing base is essential if uniformly good results are to be obtained. In some instances the extreme roughness of the base necessitates scarification and the addition of fresh material prior to the construction of the surface. The base is then compacted under traffic and rolling, using water as may be required.

After consolidation is thus secured, the road is primed, or tack-coated. Emulsified asphalt of the type used in the mixing operation is perfectly adapted to use in the preparation of cold patch material for leveling depressions and irregularities. In some cases the cross-section of the road has been corrected to the extent of placing a plant-mix, or road-mix, leveling course, prior to the construction of the coarse aggregate type wearing surface.

Primer.—After the base is properly consolidated, if previously untreated, it should be given a tack-coat, or an application of suitable priming material. If the base is sufficiently well compacted to permit of brooming until a clean surface can be produced, a very satisfactory tack-coat will consist of ¼ gallon per square yard of the quick-setting penetration emulsion, or of the mixing emulsion if the penetration emulsion is not yet available on the work. If the base is dry, dusty, and more or less unstable, the prime-coat would preferably consist of emulsified asphalt primer, applied at the rate of about ⅓ gallon per square yard, or of mixing emulsion diluted with 3 to 5 parts of water and applied in such quantity as to provide ⅓ to ¼ gallon per square yard of the emulsified asphalt. The primer and the subsequent applications of emulsified asphalt for mixing and penetration, are all applied cold, with ordinary pressure distributors.

Spreading Aggregate.—Again, reference is made to the discussions in the previous section for a full discussion of proper methods and equipment. Whether dumped from a truck or through box-spreaders, leveling with a blade-grader or drag will distribute the aggregate with sufficient uniformity for the first application of asphaltic mixing emulsion. In dry weather, or with highly absorbent aggregate, it is desirable to apply water immediately prior to the first application of bituminous material.

First Application of Emulsion and Mixing.—The application of mixing emulsion is made cold, with any suitable distributor in the quantity indicated in the Table of Materials, and immediately after the application, mixing should begin. The mixing operation with emulsified asphalt is a very simple one and may be accomplished with spring-tooth harrows and disc cultivator, or with a blade drag or other type maintenance machines which are being rapidly developed. Two or three turnings of the aggregate are sufficient. Longer mixing does not improve results and tends to increase cost.



—*From Report on Use of Bitumuls*

Broom-Drag for Finishing Surface

Leveling, Rolling, and Keying.—After the material has received its coating of mixing emulsion, it should be leveled with a suitable drag or blade to the desired cross-section. The surface should then be rolled once over to prepare for the key-stone. Following the spreading of the key-stone in the quantity indicated in the Table of Materials, the entire surface should be drag-broomed and rolled until firmly compacted. The amount of rolling must be varied according to the hardness of the aggregate.

First Application of Quick-Setting Penetration Emulsion.—After the key-stone has been rolled and broomed until uniformly compacted, the first application of quick-setting penetration emulsion is made at the rate indicated in the Table of Materials. This application of emulsion coats the freshly applied key-stone and due to its fluidity, also penetrates and coats newly fractured surfaces in the coarse aggregate and tends to build up the thickness of coating and bond where required to add to the strength of the pavement.

This first application of penetration emulsion is then followed with a cover of clean stone chips, of the size and quantity shown in the Table of Materials, and the brooming and rolling operation repeated.

Second Application Quick-Setting Emulsion.—The surface is then ready for the final application of penetration emulsion which serves to coat previously applied metal and to act as a seal coat for the pavement. This last application of quick-setting emulsion is followed with a cover of fine stone chips, or coarse sand, which is broomed and rolled and then opened to traffic. The surface so constructed is uniform in texture and resists leakage.

Broom-Drag.—In the foregoing descripion of construction methods, reference is frequently made to the use of a broom-drag. This very interesting and extremely useful piece of equipment is believed to be almost indispensable if uniformity and riding qualities are to be secured in the finished pavement.

Coarse Aggregate Type with Pre-coated Base.—In many instances it has been found economical to precoat the coarse base aggregate at the source of production, prior to being transported to the work. In such cases the coated aggregate is spread, as with the uncoated, but is immediately leveled and shaped to the required cross-section. Road manipulation of this coarse aggregate is thereby reduced to the minimum and after rolling, construction proceeds exactly as above described, including the key-stone and two penetration applications. The mixing of the aggregate at the quarry, or pit, may be economically accomplished in either a pug or drum mixer.

Recommendations.—Several features should be given special attention when emulsified asphalts are used.

1. Over-mixing of coarse aggregate with mix emulsion is undesirable and if carried to an extreme is detrimental.

2. Mixing should, if possible, be carried on immediately after the application of the mixing emulsion. If conditions prevent immediate mixing, then the mixing operation should be delayed or discontinued at the first indication of stripping. Stripping indicates partial coalescence of the asphalt in the emulsion and the material should not be manipulated while this process is under way. Under ordinary climatic conditions mixing may be resumed in a few hours, at which time it will be found that the asphalt has adhered to the stone.

3. Excessive rolling of the key-stone should be avoided, particularly where soft material is being used, as this tends to produce dust and to prevent proper penetration of the two subsequent applications of quick-setting emulsion.

4. Coarser key-stone and stone chips may be used when the stone is soft, depending upon rolling to reduce the size and to insure a dense pavement.

5. Some engineers have reported better results, particularly with dusty stone, when water is applied following the rolling of the key-stone. This tends to remove dust from the key-stone and to insure full penetration of the succeeding applications.

Minnesota counties will save more than one million dollars a year from now on by being relieved of maintenance and improvement costs on the 4,500 miles of county roads taken into the state trunk system in January, 1934. This is the estimate of the state highway department.

Bituminous Surface Treatment

Specifications, Massachusetts Department of Public Works

Description.—After the road has been surfaced with gravel or with water bound macadam as hereinbefore specified, a bituminous surface treatment shall be applied (if required under Special Provisions) in accordance with these specifications.

Materials.—The bituminous material shall consist of tar or asphaltic oil; the kind to be used and the number of gallons to be applied per square yard will be given under Special Provisions.

Tar shall be homogeneous and it shall meet the following requirements (Dept. Spec. No. 14):

1. Specific gravity 25° C./25° C. . . . . not less than 1.10
2. Water, per cent by volume. . . . . not more than 2.0
3. Specific viscosity, Engler 50 C.C. at 40° C. (104° F.) . . . . . 8 to 35
   a. For priming. . . . . Sp. vicosity 8 to 13
   b. For light surface treatment. . . . Sp. vis. 13 to 18
   c. For heavy surface treatment. . . Sp. vis. 18 to 25
   d. For mulch honeing. . . . . Sp. vis. 25 to 35
4. Total bitumen (soluble in carbon disulphide) . . . . . not less than 88%
5. Total distillate by weight (water free)
   0° C. to 170° C. . . . . not more than 5%
   0° C. to 270° C. . . . . not more than 30%
   0° C. to 300° C. . . . . not more than 40%
6. Softening point of residue from distillation test 0° C. (R. & B.) . . . . . 35 to 65

Asphaltic oil shall meet the following requirements (Dept. Spec. No. 2):

1. It shall be homogeneous and free from water
2. Specific gravity 25° C. (77° F.) . . . not less than 0.90
3. Viscosity at 50° C. (122° F.) (Furol) sec. . . 20 to 60
   Grade A for penetration. . . . . 20 to 40
   Grade B for mat building. . . . . 40 to 60
4. Loss at 163° C. (325° F.) 5 hours. . . . . 15% to 30%
5. The asphaltic content at 100 penetration. 45% to 55%
   a. Ductility of residue 25° C. (77° F.) . . . . . not less than 60 cm.
6. Total bitumen (soluble in carbon disulphide) . 99.5%

Sand shall consist of grains or particles of quartz or other hard and durable rocks. The grains shall be sharp, free from loam and clay or other foreign materials.

Construction Methods.—The surface to be treated shall be swept of all loose material with brooms or an approved sweeper. If directed the surface shall then be watered slightly. Two (2) applications of bituminous material hereinbefore described shall be applied cold in a thin film upon the surface and distributed evenly by means of an approved pressure machine, so designed as to enable its operator to control the flow and to distribute the material uniformly under a pressure of not less than thirty (30) pounds per square inch, leaving no streaks or spots and so designed as to enable its operator to "cut out" any portion of the roadway and to avoid any surplus deposit of the material on the roadway or elsewhere. If directed, the bituminous material shall also be further distributed by means of soft brooms or squeegees.

As soon as possible after each application of bituminous material, as hereinbefore specified, a thin layer of sand shall be distributed evenly thereon in sufficient quantity to absorb all surplus bituminous material and form a true surface.

No bituminous work shall be done during rainy weather nor when weather conditions as to temperature or otherwise are in the opinion of the engineer unfavorable for obtaining satisfactory results.

All unsatisfactory material shall be removed and replaced by the contractor at his own expense.

Asphaltic oils and tars delivered in tank truck distributors or tank truck feeders from refineries or distributing plants shall be weighed on scales furnished by and at the expense of the contractor. Said scales shall be sealed at the expense of the contractor as often as necessary to insure their accuracy. At the option of the Department, a sworn weigher to be appointed and compensated by the Department shall weigh all asphalt required to be weighed.

Basis of Payment.—This work will be paid for as follows:

The bituminous material will be paid for at the contract unit price per gallon applied, complete in place. For the purpose of measurement, a gallon shall be a volume of 231 cubic inches and measurement shall be based on the volume of the bituminous material at its temperature when applied. Asphaltic oil or tar delivered from refineries in tank truck distributors and tank truck feeders shall be weighed and the volume shall be computed at 60° F. on the following basis.

a. Weight of Tar at 60° F. = 9.40 pounds per gallon.

b. Weight of Oil at 60° F. = 7.80 pounds per gallon.

Asphaltic oils and tars delivered in tank cars when not actually weighed, shall be measured by volume at the loading temperature and the quantity converted to the volume at 60° F. The coefficient of expansion or contraction per degree F. shall be .00036 for asphaltic oils and .0003 for tars. In no case shall the total number of gallons of bituminous materials for any car be in excess of the United States Interstate Commerce Commission's capacity rating for that car.

The sand will be paid for at the contract unit price per cubic yard of Sand Borrow. The above prices shall include all materials, equipment, tools, labor and work incidental thereto.

Oiled Earth Surface

Specifications, Illinois Division of Highways

Description.—Oiled earth surface shall consist of treating the surface of a prepared earth grade with road oil in accordance with the requirements of these specifications.

Materials.—All road oils shall conform to the requirements of Division III, Section 67, Articles 67.1-67.6; 67.28.*

Construction Methods.—The method of preparing the surface and applying the road oil shall conform to the following requirements:

(a) *Preparation of Roadway.*—The earth roadway shall be completed in accordance with the requirements of Division II, Part A, "Earthwork," and no road oil shall be spread until the earth grade has been accepted by the engineer. If the earth grade has been previously completed, or if the new earth grade is not oiled as soon as it is completed and accepted, it shall be reshaped prior to the application of the oil. At the time the oil is applied, the surface of the grade shall be smooth and well compacted, shall be free from sod, vegetation, excess loose dirt or dust, and shall be dry enough that the wheels of the distributor will not rut or mar the surface. Excess dust or loose dirt shall be removed from the surface after the road is closed to traffic and before application of the oil. If the removal of such dust or dirt leaves an uneven or rough surface, the oil shall not be applied until the surface has been placed in an acceptable condition.

(b) *Seasonal and Temperature Limitations.*—Road oil may be spread at any time during the period June 1 to September 15, provided the air temperature is above 70° F. and the road is dry.

(c) *Quantity of Oil.*—The total quantity of oil applied shall be not less than one-half (½) gallon per square yard of surface.

(d) *Application of Oil.*—The oil shall be brought to a temperature of from 120° to 200° F., depending upon the temperature of the air, the viscosity of the oil, and the length of haul from the heating plant. The temperature at the time of application shall be such that the oil will spray uniformly, without clotting or stringing at the spraying nozzles.

The oil shall be applied by means of a pressure distributor, so equipped as to insure uniform distribution, and so regulated that the required width to be oiled can be covered without overlapping.

The oil shall be applied in two (2) applications of one-fourth (¼) of a gallon each. Sufficient time shall elapse between successive applications to permit the absorption of the oil to such extent that the soil will not adhere to the wheels of the distributor.

The road shall be closed to traffic during the application of the oil, and shall remain closed for a period of not less than forty-eight (48) hours after the final application, or longer if deemed necessary by the engineer. Excess oil remaining on the surface at the time the road is opened to traffic shall be covered with a thin layer of loose earth sufficient to absorb the surplus oil.

Basis of Payment.—This work shall be paid for at the contract unit price per square yard for "Oiled Earth Surface," which price shall be payment in full for furnishing all materials, labor, equipment, tools, and incidents necessary to complete the work as specified herein.

ROAD OIL: PO.—(For surface treatment of earth roads.) The road oil shall be produced from domestic petroleums, shall be homogeneous, and shall conform to the following requirements:

Item Test	E-2 Light	E-3 Medium	E-4 Heavy
(a) Water, by volume, not more than....	0.5%	0.5%	0.5%
(b) Flash point (open cup), not less than.	176° F.	176° F.	176° F.
(c) Specific gravity at 60° F./60° F.	0.920-1.050	0.930-1.060	0.935-1.070
(d) Viscosity, Saybolt Furol, at 122° F., seconds	80 to 135	135 to 240	240 to 370
(e) Bitumen soluble in carbon disulphide, not less than.....	99.5%	99.5%	99.5%
(f) When the specific gravity at 60° F./ 60° F. is less than 0.960 for E-2, 0.970 for E-3, and 0.980 for E-4 oils, bitumen insoluble in paraffin naphtha shall be not more than	8.0%	9.0%	10.0%

*In addition to the general provisions covering sampling, testing, measurement, etc., of bituminous materials, these references include the following:

Developments in the Use of Tar for Highways in 1933

An Article by Geo. E. Martin, Consulting Engineer, General Tarvia Department, The Barrett Co., New York City, published in Roads and Streets for January, 1934.

The year 1933 has been marked by a gradual development and improvement in the use of tar rather than any sudden and drastic changes. The tried and tested materials and methods over a long period of years have not been abandoned and replaced by entirely new things. Rather the old stand-bys have been retained in their main



Building Tarvia-Lithic Surface in Winter in New Jersey

features and only changed and modified to utilize new knowledge as it has been obtained. For that reason, the developments recorded here will not be dramatic and unprecedented but they are important, nevertheless.

Surface Treatments.—Formerly, prime coat tars, with an Engler Specific Viscosity at 40° C. of 8 to 13 or 13 to 18, were always used and their well-known penetrating and binding properties depended upon for consolidating the sand-clay, sand, gravel or macadam surface. This is still a very successful practice in many sections of the country. However, some road officials have wished to obtain the penetration into the top crust by mixing the tar and aggregate by means of a blade grader, maintainer, drag or similar machine. While good work is done with the prime coat tars, somewhat heavier materials, having an Engler Viscosity at 40° C. of 18 to 25 or 25 to 35, are being used. These materials set up somewhat more quickly under traffic and the mixing operation insures as complete penetration as when the lighter materials are used.

In the realm of the so-called cold surface treatment materials, defined as those which can be removed from the tank car without heat although they must be warmed for use on the road, a new grade of material with an Engler Specific Viscosity at 50° C. of 26 to 36 has been utilized. This grade was developed as a "re-tread" binder but has proved to be a successful surface treating material. Its chief use has been in the re-treatment of bituminous surfaces and the surface treatment of concrete and brick. It produces a somewhat heavier and tougher surface treatment than the lighter cold surface treatment materials and while it sets quicker it can still be dragged like them.

Many new gravel roads have been treated with tar during their construction. Cold surface treatment or light re-tread binders have been used for this purpose. Mixing machines of various sorts have been used to mix the tar and gravel. Usually the top 3 or 4 inches of the gravel has been mixed with the tar using about ⅔ gal. of tar per square yard. A seal coat of approximately ⅓ gal. of the same grade of tar was used.

Dragging of surface treatments has steadily increased. This operation distributes the tar over the surface of the covering aggregate. It also results in much easier riding surfaces. All of the cold surface treatment tars and the "re-tread" binders can be dragged. Hot surface treatment tars should not be dragged under ordinary circumstances, but the cover may be broomed or broom dragged and rolled.

Another use for the surface treatment tars has been in their application to slippery roads to produce non-skid surfaces. The tars adhere to the smooth, slick surfaces and hold the aggregate placed on them with their granular texture exposed to grip the tires and hold the vehicles in place. This is a permanent and not a temporary condition since the tars will not bleed up over the top of the aggregate.

Re-Tread.—The "re-tread" or mixed-in-place type has continued to increase in popularity due to its inherent qualities and to the growing demand for low cost highways.

As highway officials have become more familiar with the type and better organized to carry out the work, there has been a demand for methods and materials which would permit the work to be finished more quickly. To meet this demand, heavier tars have been developed, present general practice being to use those with an Engler Specific Viscosity at 50° C. of 16 to 22 for winter, spring and fall work and 26 to 36 for summer work. In some instances a hot surface treatment tar with a float test at 32° C. of 60 to 150 seconds has been used.

When the heavier tars are used all of the binder is sprayed at one time and the seal coat spread in two applications.

In this type of construction all of the stone for the total depth is spread on one side of the road. Tar is



Spreading Tar on Gravel on a New York State Road

then sprayed on the stone at the rate of approximately 1½ gals. per square yard for the 5-in. depth of stone over half the width of the road. The tar and stone is then turned over a few times, spread out over the road surface and rolled. The surface voids are then filled with small-sized stone chips, New York uses No. 1A stone ranging in size from ⅛ in. to ¼ in. on square mesh screens. This material is swept into the voids during

the rolling. A first seal coat of the same grade of tar used for the mixing is applied at the rate of approximately ¼ gal. per square yard. This treatment is covered, swept and rolled and a second seal coat of the same amount applied. Covering, sweeping and rolling completes the job. The amount of tar required would be as follows:

	gal. per sq. yd.
Mixing	.75
First seal	.25
Second seal	.25
Total	1.25

This modified type of re-tread permits the rapid construction of the road where the work is well organized and plenty of equipment available.

Plant Mixes.—Plant mixes, using tar binders, have been of the hot mix, cold laid variety. Usually the materials are produced to meet definite specifications and such changes as have been made were made to meet the desire of the customer. In this connection, there has been a tendency to require somewhat smaller aggregate and a tighter, more thoroughly filled surface. This has been true in all sections of the country, except New England, where the engineers desire an open, rough textured surface.

Practically all of the mixed material is now hauled from the plant to the job in trucks. Car shipments are the exception rather than the rule.

Plant mixes were used extensively during the year for the re-surfacing of concrete, brick and similar pavements.

There is a growing tendency on the part of political organizations to use plant-mixed tar concrete for maintenance work rather than mix their own.

Winter Work.—Not so long ago all road work, except in the extreme southern states, stopped during the winter months. However, during the past year there has been a demand for continued public works in the winter when



Tar Gravel Mulch on a Road in New England

the unemployment situation is most critical. This condition has not changed for this winter. As a result of this demand, tar was used during all of the months of the winter of 1932-1933. As a general proposition, the liquid tars can be successfully applied when the road is damp, but not wet. Covering and rolling operations must follow closely behind the application of the tar. The plant-mixed tar concrete can be very readily handled during the winter.

One example of work of this sort, using a tar-bound macadam foundation and a "Tarvia-lithic" (plant-mixed tar concrete) top, is the paving of Glenside Ave., near Summit, N. J., for the Highway Department of Union County. This work was fully described in the November 1933 issue of ROADS AND STREETS.

Standard Grades.—An effort has been made during the year to select standard names and consistencies for the various grades of tar used for highway work. The following grades have been tentatively selected for coal



Mixing Tar and Gravel on a New York State Road

tar road materials and are now being considered by the various interested parties.

Suggested Grades—Coal Tar for Highway Use

Use	Name	Consistency
Prime coat	TC–1	Spec. Visc., Engler, 50cc at 40°C. 8–13
Prime coat	TC–2	Spec. Visc., Engler, 50cc at 40°C. 13–18
Cold surface treatment	TC–3	Spec. Visc., Engler, 50cc at 40°C. 18–25
Cold surface treatment	TC–4	Spec. Visc., Engler, 50cc at 40°C. 25–35
Re–tread binder	TM–1	Spec. Visc., Engler, 50cc at 50°C. 16–22
Re–tread binder	TM–2	Spec. Visc., Engler, 50cc at 50°C. 26–36
Hot surface treatment	HT–1	Float Test at 32°C. 60–150 seconds
Hot surface treatment	HT–2	Float Test at 32°C. 150–210 seconds
Crack filler and binder	TP–1	Float Test at 50°C. 100–160 seconds
Penetration macadam	TP–2	Float Test at 50°C. 160–220 seconds
Cold Patch	TCP–1	Spec. Visc., Engler, 50cc at 40°C. 35–60
Cold patch	TCP–2	Spec. Visc., Engler, 50cc at 40°C. 60–80

Conclusion.—The year has been marked by a gradual change in the use of tars in highway work rather than any sudden and complete overthrow of the old methods with the substitution of new ones. New ideas have been adopted but their introduction has been gradual so that their advantage has been obtained without the risk of new and untried experiments.

Protection of Sheet Asphalt

If at the time of laying binder and surface course mixtures, permanent side supports, such as curbs, edgings, or gutters have not been constructed, planks of suitable thickness shall be laid along each side of the pavement and rigidly supported, so as to prevent the mixture from squeezing out under the roller. These planks shall remain in place until final compaction has been obtained. Sections of newly compacted binder and wearing courses shall be protected from traffic for at least six (6) hours or until they have become properly hardened by cooling. —*From Specifications for Sheet Asphalt Binder and Surface Courses, Illinois Division of Highways.*

A Laboratory Traffic Test for Low-Cost Road Types

The U. S. Bureau of Public Roads has recently built and placed in operation at the Arlington Experiment Farm a small circular test track for applying, in the laboratory, traffic tests to sections of highway surfaces. The test was designed primarily for the study of low-cost bituminous types, but it is believed that it may be adapted for other studies such as, for instance, subgrade stabilization, motor-vehicle tire wear, etc.

The track consists of an annual concrete trough 12 in. deep, 18 in. wide, and 12 ft. in diameter at the center line. The depth is sufficient to permit the use of various combinations of base materials beneath the bituminous test surfaces. Along the smaller circumference of the trough in which the test sections are held and cast integrally with it, is another trough 3 in. wide and 13 in. deep intended to be used as a reservoir for the introduction of water into the base material under the test surfaces through small openings at the base of the partition wall. By this arrangement the track may be flooded or the water may be introduced through capillarity.

Two full-size automobile wheels provide the traffic for the tests. These wheels are fixed to the two ends of a rigid structural member which is rotated in a horizontal plane by a vertical shaft in the pedestal at the center of the track. The upper end of this shaft is squared and on it rides a freely sliding square nut mounted in trunnions in the cross member. This arrangement causes a constant wheel load (that due to the weight of the wheels, tires, and cross member) to be applied at all times regardless of the irregularities of the test surfaces. At present this load amounts to about 800 lb. per tire. Although the distance between the two test wheels is fixed, a handwheel adjustment is provided which shifts the position of the square nut with respect to the midpoint of the cross member and enables the operator to place the path of either wheel at any point on the test surface.

An electric motor operating through a 3-step cone pulley and a worm reduction drives the vertical shaft at the center of the track.

The test wheels may be operated at speeds of 4½, 6, or 9 miles per hour as desired. The low speed has proved to be most convenient when distributed traffic for compacting the surface is required. For the testing of the completed surfaces, concentrated traffic and the highest speed are used.

The number of trips made by each wheel is recorded by an electrical contact mechanism on the central vertical shaft operating a magnetic revolution counter at a point outside the track. In addition to this record, the data being collected include the corresponding behavior of the material under test, the density of the surface before and after test, oil migration, water content, and amount of material lost due to raveling. It is hoped that this information will make possible the evaluation of the important factors affecting the behavior of oiled aggregate mixtures.

The apparatus is now being used to investigate the effect of the percentage and consistency of the bituminous material on the durability and stability of mixtures with one type and grading of aggregate. A later phase of this series of tests will involve a study of the effect of capillary water on the same mixtures. Various other factors influencing the behavior of different types of bituminous surface will be studied.

From the preliminary work which has been done up to this time it appears that the apparatus will provide a very useful method of studying some of the many factors involved in the performance of low-cost bituminous surfaces.—*From Roads and Streets for June,* 1933.

Weights and Mortar Per Joint For Vitrified Pipe

From Standards for Field and Office Practice Kentucky State Department of Roads.

Inside diam.	Single strength pipe			Wt. per	Double strength pipe			Wt. per	Lin ft. Mortar per jnt.	Lin. ft. c. y. per sk. of sand	
in.	t	b	c	foot	t	b	c	foot	cu. ft.		cement
	in.	in.	in.	lb.	lb.	in.	in.	lb.			
15	1⅛	2½	½	60	1¼	2½	½	75	.092	942	35
18	1¼	2¾	½	85	1½	2¾	½	118	.118	717	27
20	1⅜	3	½	100	1⅝	3	½	138	.142	605	22
24	1⅝	3¼	½	150	2	3¼	½	190	.189	449	17
30	2¼	4	¾	252	2½	4	¾	290	.373	350	13
36	2½	5	1¼	350	2¾	5	1¼	375	.764	168	6

Quantities figured for 2 ft. lengths to 24 in. diameter and 3 ft. lengths above 24 in. Note—t = thickness of shell; b = depth of socket; c = thickness mortar joint. Mortar is 1:1 mix.

Weather Conditions and Working Days

By C. N. Conner and P. F. Seward, Engineer Executive and Assistant Engineer, American Road Builders' Association

The practice of the contractor bidding the number of working days and this item receiving a monetary consideration in the award is rapidly being discontinued, and is being replaced by a date set by the engineer for the completion of the work.

In the 48 states only 4 require or permit the contractor to bid the number of working days. In the other 44 states the date of completion is set by the state highway department. This fact should influence contractors to make a careful check of the average weather conditions for the immediate territory in which the project is situated, in order that he may intelligently decide as to the equipment which he will place on the work and his method of procedure.

To aid the contractor in this respect we have carefully compiled Table I, showing the following information for the various sections of each state:

Working Days for Grading.

Working Days for Paving.

Mean Annual Precipitation.

Mean High Temperature.

Mean Low Temperature.

Mean Frost Date—Spring.

Mean Frost Date—Fall.

Conclusions Regarding Weather Conditions.—These data show average weather conditions which when applied give the following conclusions:

Grading—Working days vary from 140 to 300.

Paving—Working days vary from 100 to 300.

Precipitation ranges from 7.21 in. to 55.82 in.

Maximum average high temperature 113 deg. in Arizona and New Mexico.

Minimum average low temperature 52 deg. below zero in Montana.

In Florida the average last date of frost in the spring is March 10 and the first in the fall Dec. 1.

In Wyoming the last frost in the spring averages July 15 and the first frost in the fall averages Aug. 10.

Table I.—Working Days and Climatic Conditions in the Several States for Highway Construction; Average for Entire State, Number of Working Days Per Year, Exclusive of Sundays, Holidays and Bad Weather.

State	Portion	*Working Days Grading	*Working Days Paving	Mean Annual Precipitation Inches	Temperature Mean High	Temperature Mean Low	Mean Frost Date Spring	Mean Frost Date Fall
Ala.	N. & W.			49.00	105	— 9	Apr. 25	Oct. 15
	E., C. & S.	240	240–300	55.32	105	0	Apr. 20	Oct. 15
Ariz.	Southern			10.95	113	+ 9	Apr. 15	Oct. 25
	Northern	200–300	200–300	16.12	107	—10	June 1	Sept. 20
Ark.	Southern			46.22	108	— 9	Mar. 20	Nov. 10
	Northern	300	300	47.25	109	—17	Apr. 15	Oct. 15
Calif.	Southern			14.10	110	+15	Apr. 10	Nov. 1
	Central			18.85	111	+17	Apr. 20	Oct. 15
	N. Eastern			34.81	108	+ 4	June 1	Oct. 5
	N. Western	155–300	120–300	40.22	107	+14	May 25	Oct. 15
Colo.	S. Eastern			17.30	99	—30	June 15	Sept. 15
	N. Eastern			16.88	99	—32	June 25	Sept. 15
	Western	No Data	No Data	17.03	94	—33	July 1	Sept. 5
Conn.		180–210	125–155	42.01	99	—24	June 5	Sept. 10
Chesapeake Bay Region				42.82	104	—11	May 5	Oct. 25
Fla.	Northern			53.60	103	+10	Apr. 15	Nov. 1
	Southern	240	240–up	41.43	99	+22	Mar. 10	Dec. 1
Ga.	Western			52.48	104	— 4	Apr. 25	Oct. 20
	Cent. & East.	300	300	49.44	107	— 2	Apr. 20	Oct. 15
Ida.	Northern			23.22	103	—24	June 25	Sept. 1
	Southern	120–200	80–120	14.56	105	—29	July 1	Sept. 1
Ill.	Northern			33.12	107	—27	June 1	Sept. 15
	Central			36.04	106	—25	May 15	Sept. 20
	Southern	180–240	125–135	41.41	109	—20	May 10	Sept. 25
Ind.	Northern			36.07	105	—23	May 25	Sept. 15
	Southern	160–175	120-140	42.52	107	—22	May 15	Sept. 20
Iowa	Western			32.39	108	—36	May 20	Sept. 15
	Central			32.39	108	—33	May 20	Sept. 15
	Eastern	175	125	32.39	107	—31	May 25	Oct. 5
Kan.	All	200	140	28.50	111	—27	Apr. 25	Oct. 20
Ken.	Eastern			46.87	104	—20	May 10	Sept. 25
	Western	175	100	45.40	106	—21	May 10	Sept. 25
La.	Southern			56.37	106	+ 7	Mar. 10	Nov. 15
	Northern	225	225	49.32	107	— 2	Apr. 20	Oct. 20
Maine	All	140	110	40.66	98	—29	June 15	Sept. 10
Mass.		225	150	42.01	99	—24	June 5	Sept. 10
Mich.	Upper Penin.			30.00	99	—37	June 15	Sept. 1
	Western Lower			31.00	102	—29	June 5	Sept. 10
	E. Lower	180	130	32.00	103	—29	June 15	Sept. 10
Minn.	S. Western			25.31	104	—38	May 15	Sept. 25
	S. Eastern			28.65	105	—40	May 15	Oct. 1
	Northern	150	100	24.98	102	—48	June 15	Sept. 1
Miss.	Northern			49.30	104	— 6	Apr. 25	Oct. 10
	Southern	240	160	55.82	104	+ 2	Apr. 20	Oct. 20
Mo.	S. Western			40.00	109	—27	May 15	Sept. 20
	S. Eastern			44.98	109	—24	May 15	Sept. 25
	Northern	No Data	No Data	36.67	109	—26	May 15	Sept. 25
Mont.	S. Eastern			14.35	106	—45	June 10	Sept. 1
	S. Western			15.05	101	—43	June 20	Aug. 20
	Western			17.82	102	—33	June 20	Aug. 25
	N. Central			16.00	102	—46	June 20	Aug. 25
	N. Eastern	No Data	100–120	14.27	108	—52	June 15	Aug. 25
Neb.	N. Western			19.75	106	—35	June 5	Sept. 10
	N. Eastern			27.75	109	—36	May 25	Sept. 15
	Southern	250	225	25.00	111	—33	May 25	Sept. 15
Nev.	All	240–300	150–175	7.21	106	—21	June 25	Sept. 1
N. H.		140	100	42.01	99	—24	June 5	Sept. 10
N. J.	S., I. & Coast			47.68	103	—10	May 20	Sept. 25
	Northern	190	140	47.44	104	—18	May 20	Sept. 20
N. M.	W. & S.			13.43	113	—18	May 7	Oct. 20
	N. Western			14.09	100	—22	June 15	Sept. 25
	N. Eastern	No Data	No Data	17.87	102	—20	May 25	Oct. 1
N. Y.	Western			35.20	99	—23	June 10	Sept. 10
	Central			39.09	98	—30	June 10	Sept. 10
	S. Central			38.76	99	—30	June 15	Sept. 10
N. C.	Eastern	160	150	41.68	100	—24	May 25	Sept. 15
	E. & W.			51.66	98	—16	May 20	Sept. 25
	W. Central			51.46	102	— 7	May 5	Oct. 5
	C. & S. E.			48.06	104	— 4	May 5	Oct. 10
N. D.	N. Eastern	200	200	48.23	102	— 2	Apr. 25	Oct. 15
	Western			15.69	105	—47	June 15	Aug. 25
Ohio	Eastern	150	180	19.26	105	—46	June 15	Aug. 20
	Northern			36.74	104	—23	June 1	Sept. 15
	S. Western			39.36	105	—24	May 20	Sept. 25
	S. Central			38.68	105	—26	May 25	Sept. 20
Okla.	S. Eastern	No Data	No Data	39.38	104	—26	May 25	Sept. 20
	Eastern			38.75	110	—14	Apr. 25	Oct. 10
Ore.	Western	225–240	225–240	30.00	112	—14	May 1	Oct. 1
	Western			51.44	101	— 5	June 1	Sept. 25
Pa.	Eastern	No Data	No Data	14.00	104	—24	June 20	Sept. 10
	Western			41.41	103	—14	June 5	Sept. 15
	Central			40.08	103	—24	June 5	Sept. 15
Potomac	Eastern	190	120–140	46.09	103	—18	May 20	Sept. 20
R. I.	River Basin			39.37	104	—19	May 15	Oct. 5
S. C.		190–200	140–150	42.01	99	—24	June 5	Sept. 10
	Western			48.75	105	— 1	Apr. 20	Oct. 15
S. D.	Eastern	210–240	180–240	47.16	105	+ 2	Apr. 15	Oct. 20
	Western			18.50	108	—40	June 1	Sept. 5
Tenn.	Eastern	130–165	110–140	22.30	107	—42	June 25	Sept. 1
	Middle West			50.83	104	—18	May 15	Oct. 1
Texas	Eastern	190	175	51.66	98	—16	May 20	Sept. 25
	N. Western			24.50	109	—10	May 10	Oct. 15
	Central			26.50	110	— 4	Apr. 25	Oct. 20
	Eastern	240–300	180–240	40.00	111	— 5	Apr. 25	Oct. 20
	Southern			31.88	107	+ 8	Apr. 5	Oct. 25
Utah	W. & S.			13.43	113	—18	May 7	Oct. 20
	Eastern			11.13	104	—25	June 20	Sept. 10
Va.	Western	170-180	170–180	13.93	103	—23	June 25	Sept. 10
	South & S. W.			43.60	100	—19	May 20	Sept. 25
	S. & E.			42.87	102	— 4	Apr. 25	Oct. 10
Vt.	Central	180–210	150–180	41.60	104	—13	May 15	Oct. 5
Wash.		155	115	42.01	99	—24	June 5	Sept. 10
	Western			49.14	97	0	May 25	Sept. 25
W. Va.	Eastern	180–300	150–240	15.48	107	—24	June 25	Sept. 15
	Northern			45.84	103	—26	May 30	Sept. 25
Wis.	S. & S. W.	No Data	120–180	43.60	100	—19	May 20	Sept. 25
	N. Western			30.00	101	—43	June 10	Sept. 5
	Central			32.00	102	—41	June 10	Sept. 5
	Eastern	140–150	110	31.40	106	—32	June 1	Sept. 20

Water Supply in Road Construction

Pumping Data

From the Pumping Guide of the Domestic Engine & Pump Co.

How to Determine the Power Required for Pumping.—The power required for pumping depends primarily upon two factors—the weight of liquid to be pumped per minute and the vertical height it has to be raised from source of supply to the point of delivery. In addition to these two principal factors, allowance must be made in practice for the losses in the pumping equipment and the friction in the pipe lines.

A practical formula in common use for determining the H. P. required for pumping water is:

$$\frac{\text{G. P. M.} \times \text{H.}}{4{,}000 \times \text{E.}} = \text{H. P.}$$

G. P. M. = Gallons of water per minute.
H. = Total working head.
E. = Efficiency of the pump and gearing, expressed as a decimal.

Illustration.—We wish to pump 30 gal. per minute. The distance from source of supply is 1½ miles to discharge point, and the highest point of elevation from surface of water at source to discharge point is 70 ft. Our pipe line will be 2-in. pipe, and we need 8 ninety-degree elbows in the line. What horsepower engine should we use?

From table of friction of water in pipes we get the following:

Added friction head in each 100 ft. of 2-in. pipe discharging 30 gal. of water per minute = 2.09 ft. For 7,920 ft. = 79.2 × 2.09 = 165.53 ft. (if old rough pipe is used add 30%).

From table Friction in Elbows, we get:

Added friction head for each 90 degree elbow, 2-in. size, discharging 30 gal. per minute = .127 ft. Eight elbows = 8 × .127 = 1.016 ft.

The total working head, therefore, is 70 + 165.53 + 1.01 = 236.54 ft.

The efficiency for the average small force pump is 50%.

Substituting these values in our formula

$$\frac{\text{G. P. M.} \times \text{H.}}{4{,}000 \times \text{E.}} = \text{H. P.}$$

we get

$$\frac{30 \times 236.54}{4{,}000 \times .5} = 3.54 \text{ H. P.}$$

Wrought Iron or Steel Pipe

Full Weight—Black and Galvanized, for Steam, Gas and Water. Standards Adopted January 1st, 1913.

Size	Diameter		Thickness	Weight per ft., lbs.		Threads per Inch
	External	Internal		Plain Ends	Threaded & Couplings	
2	2.375	2.067	.154	3.652	3.678	11½
2½	2.875	2.469	.203	5.793	5.819	8
3	3.500	3.068	.216	7.575	7.616	8

The permissible variation in weight is 5% above and 5% below. Pipe smoothed on inside is known as Reamed and Drifted. Extra Strong and Double Extra Strong Pipe both have the above given External Diameter but have smaller Internal Diameter.

Table giving the friction head in feet for each 100 ft. in length of clean, staight iron pipe, discharging given quantities of water per minute

Gallons per Minute	Size of Standard Iron Pipe		
	2-in.	2½-in.	3-in.
25	1.43	.485	.231
30	2.09	.693	.300
35	2.76	.92	.393
40	3.68	1.19	.53
45	4.60	1.49	.647
50	5.61	1.86	.80
60	8.88	2.70	1.15
70	11.09	3.46	1.385
80	14.55	4.63	2.08
100	21.75	7.36	3.01
125	34.27	11.24	4.57
150	48.76	16.10	6.55
175	....	21.75	8.85
200	....	28 68	11.54
250	....	....	17.84
275	....	....	20.09
300	....	....	25.76

a hose connection is used to feed the mixer. These hose

Table giving the friction head in feet for each elbow used in line of pipe discharging a given quantity of water per minute

Gallons per Minute	Size of Standard 90-Degree Elbows		
	2-in.	2½-in.	3-in.
25	.087		
30	.127		
35	.175	.085	
40	.226	.049	
45	.288	.143	.059
50	.353	.185	.074
60	.507	.258	.101
70	.701	.341	.138
80	.925	.452	.184
100	1.412	.738	.295
125	2.24	1.175	.462
150	3.205	1.58	.659
175	....	2 16	.899
200	....	2.955	1.18
250	....	....	1.845
275	....	....	2.35
300	....	....	2.63

When Pipe or Elbow is slightly rough add 15%.
When very rough add 30%.

Theoretical Discharge of Nozzles in U. S. Gallons per minute

Head		Diameter of Nozzle in Inches				
Pounds	Feet	½-in.	⅝-in.	¾-in.	⅞-in.	1-in.
10	23.1	23.6	36.9	53.1	72.4	94.5
20	46.2	33.4	52.2	75.1	102.	134.
30	69.3	40.9	63.9	92.	125.	164.
40	92.4	47.3	73.8	106.	145.	189.
50	115.5	52.8	82.5	119.	162.	211.
60	138.6	57.8	90.4	130.	177.	231.
70	161.7	62.5	97.7	141.	191.	250.
80	184.8	66 8	104.	150.	205.	267.
90	207.9	70.8	111.	160.	217.	284.
100	230.9	74.7	117.	168.	229.	299.
125	288.6	83.5	130.	188.	256.	334.
150	346.4	91.5	143.	206.	280.	366.
175	404.1	98.8	154.	222.	302.	395.
200	461.9	106.	165.	238.	323.	423.

NOTE—With smooth taper nozzles the actual discharge is about 94% of the figures given in table.

Number of Feet to be Added to Lengths of Straight Pipe for Each Globe Valve

Size Globe Valve threaded for pipe	2-in.	2½-in.	3-in.
Added feet due to friction	8	12	24

Size of Pipe and Quantity of Water in Concrete Road Construction

Extract from an article, "Efficiency in Concrete Road Construction," by J. L. Harrison, Highway Engineer, U. S. Bureau of Public Roads, in the January, 1926, issue of Public Roads.

The water used in mixing—and in curing as well—is as truly one of the materials entering into the construction of a concrete pavement as are cement and stone. With the water, as with the stone or the sand, methods of handling and means of delivery are vital factors in efficiency. Only one system of handling water is in common use today. It is pumped through a pipe line laid along the right of way to the mixer. In the common practice provision is made at regular intervals—generally 200 to 300 ft.—for taking water from the pipe line, and

connections are also used to obtain water for sprinkling and for any other job requirements. A study of the "lost time" on the job will show that the time lost as a result of trouble with the water supply is rather a large item. There is, then, ample justification for an analysis of the methods and equipment in use, for it is quite as essential that the water supply equipment shall be adequate as that the truck supply shall be adequate. Probably from the engineering standpoint it is more important, for, while production is somewhat affected by current practices, quality probably is more affected.

Basically, the water trouble on almost all concrete jobs today is inadequate water delivery facilities. With full production, a batch is produced every 1¼ minutes. Few jobs, it is true, maintain this rate consistently over any extended period, but a good many reach it not infrequently for a few minutes at a time. This rate, then, sets the water delivery rate. At least ¼ minute is required in discharging the measuring tank. A full minute is, therefore, all that can be allowed for the delivery of the water for a batch of concrete. A 1-in. slump normally requires between 5 and 6 gals. of water per bag of cement—roughly 30 gal. per standard batch which, under the assumptions made above, is equivalent to 30 gal. a minute. In addition to this, water is required for curing. With full production and a 10-day curing period it will be necessary continually to provide for curing nearly 2 miles or about 20,000 sq. yd. of paving. Rates of production as high as this are rare, but rates of production which will require the proper care of at least 15,000 sq. yd. of paving though not the rule are not uncommon. To cure concrete properly requires that the earth covering shall be kept moist—not merely that it shall be wet down once in a while; and rates of evaporation from loose soil, such as that used for covering the pavement during the curing period, are high. In fact, the evaporation from such soil when the temperature is high, the humidity low, and a brisk breeze is blowing—typical summer conditions over the greater part of the United States—will often exceed ⅓ in. per day and may even exceed ½ in., equivalent to from 2 to 3 gal. per square yard of pavement. These are, of course, the highest rates of evaporation likely to be met but as it is at just these times that full protection of the pavement is most required, they must be considered the governing rates.

Finally, the contractors properly prefer to conduct all their operations simultaneously. For that reason, though night sprinkling may at times be practiced, the contractor generally desires to attend to it during the day as the work is then under the observation of his regular foreman. The inspector also has a better grasp on the situation if it is done at that time, and, of course, during very dry weather a night wetting is not sufficient to keep the pavement moist throughout the following day. It is, therefore, proper to view the pavement-curing problem as one which under full production may involve the daily delivery of from 40,000 to 60,000 gal. of water in addition to mixer requirements and even under normal current production standards the daily delivery of from 30,000 to 40,000 gal. of water in excess of mixer requirements.

As shown above, full production at the mixer requires for mixing the concrete a somewhat variable amount not ordinarily exceeding 15,000 gal. per day. For current high rates of production at the mixer the requirements of the mixer seldom exceeds 12,000 gal. a day (10 hours). To these amounts there must be added a somewhat variable amount for wetting down the subgrade. It is therefore apparent that while a pump capable of delivering 100 gal. per minute has sufficient capacity to meet all needs that will ordinarily arise until the production of 18-ft. pavement exceeds 750 ft. a day, it is apt, at times, to prove inadequate where more than this amount of pavement is being produced unless it is worked a few hours overtime.

One thing, however, must be emphasized—namely, the adequacy of the pumping plant depends absolutely on the use of a pipe line of such size that the pressure head will always be within the limits for which the pump is designed. There are vital differences between a pump designed to deliver 100 gal. a minute against a pressure head of 100 lb. and one designed to deliver at the same rate against a pressure head of 400 lb. This raises the question as to what pressure head is required in delivering water. Table I gives the pressure head in pounds for various rates of delivery in gallons per minute, per mile of common iron pipe such as is generally used on paving jobs and while the pipe is in fair condition. As the pipe becomes somewhat battered, twisted, and rusty with use, the pressure head required to force water through it will increase so that, in a general way, the figures given are minimum figures, which may be exceeded somewhat after the pipe has been in use a few years.

The pressures given in the table are the number of pounds, as read on the gauge at the pump, which will be required to deliver the stated number of gallons per minute at the outflow end of a pipe line I mile long. Thus, if 50 gal. per minute are required and a 2-in. pipe a mile long is to be used, the gauge at the pump must be run up to 227 lbs. If 100 gal. are desired 1 mile from the pump and a 2-in. line is used, the gauge pressure at the pump must be run up to 820 lb., and if this rate of delivery were required 3 miles from the pump the gauge pressure would have to be run up to 2,400 lb. Of course, neither ordinary pipe nor ordinary pumps will stand any such pressures. The point, however, is that here is the explanation of the poor water supply so common on paving jobs today. Contractors are attempting the impossible. A fully adequate water supply for maximum requirements simply can not be driven through a 2-in. pipe 2 or 3 miles long. If the pump were strong enough to do it, the pipe would not stand it. The remedy lies in a larger pipe. One hundred gallons of water per minute can be driven through nearly 2 miles of 3-in. pipe with the same gauge pressure—i. e., the same effort on the part of the pump—which is required to drive it one-quarter mile through a 2-in. pipe.

Table I.—Pressure required at pump for each mile of pipe line to secure desired discharge, through 2, 2½ and 3 in. ordinary iron pipe*

	Number of gallons to be pumped per minute, or per 10-hour day													
Diameter of pipe	20 12,000	25 15,000	30 18,000	35 21,000	40 24,000	45 27,000	50 30,000	60 36,000	70 42,000	80 48,000	90 54,000	100 60,000	110 66,000	120 72,000
	Pressure required at pump, pounds per square inch													
2 in.	42	62	88	117	151	188	227	318	421	543	673	820	982	1,145
2½ in.	14	21	30	39	50	62	76	106	142	181	224	275	330	385
3 in.	6	9	12	16	21	26	32	44	59	75	93	114	137	161

*Based on Williams and Hazen's hydraulic tables.

NOTE—To obtain the total pressure against which the pump must work, multiply the figures given in the table beneath the desired gallons per minute and opposite the desired diameter of pipe by the total length of the pipe line in miles and then add to this product the figures obtained by multiplying the use of the pipe line in feet from the pump to the discharge end by 0.434.

With no other consideration than the water supply for the mixer, contractors could well afford to use 3-in. pipe, for its use would result in a water delivery at a pressure far less destructive of pumps, line, hose, mixer valves, etc. The added cost of pumping enough for adequate curing and, subgrade sprinkling would be so slight that the problem would cease to be troublesome.

In addition to reducing lost time at the mixer, the installation of the 3-in. pipe would permit the use of relief valves which would protect the pipe line, hose, and mixer valves against excessive pressure. Gauges should also be installed at the pump, and instead of permitting pumps to run wide open their speed should be controlled according to the rate of delivery desired and the distance this delivery must be pumped. Thus, as an illustration, if the maximum water requirement is 60 gal per minute through 2 miles of 3-in. pipe line, the pumping engine should be cut down to a speed which will produce a pressure of about 150 lb. at this delivery. The relief valve at the pump should then be set at slightly above this pressure, while the relief valve at the mixer might be set at 50 lb. or even less. This practice saves wear and tear on the pump and tends to avoid the breakdowns which occur most frequently when machines operate close to or above rated capacity.

Water Required for Concrete Paving

The State Highway Department of Pennsylvania compiled the following information for use in determining the sizes of pipe line to be used for the water supply on concrete paving projects. The information is based upon 50 per cent of the water being required for curing and 50 per cent being required for the mixer and subgrade curing. The department states that if calcium chloride is used for curing the amount of water required for the lengths paved per hour can be reduced one-half.

The tables given under the sizes of pipe lines are figured without modifications for head, and the table at the bottom of the tabulation gives the information for the correction for the head.

The tables are based on a requirement of 8,000 gal. of water for 100 ft. of paving apportioned as follows: ½ for curing, ¼ for subgrade, ¼ for mixer. The pavement is assumed to be 18 ft. wide. The head given is based on friction loss only. To this must be added the height of the outlet of the pipe above the source of supply.

How the Tables Are Used.—Example (1):

Estimated progress of paving 70 ft. per hour. Water required—5,600 gal. per hour.

Maximum water pressure in pump—150 lb. per square inch.

Pipe 2-in. diameter, pump 12 ft. above level of supply. Outlet 40 ft. above pump.

How far from the pump can the work be supplied?

150 lb. pressure = 345 ft. head as per conversion table. 345 — 12 — 40 = 293 ft. net head.

The head required for 1 mile of pipe is 1,083 ft.

Distance water can be supplied = $\frac{293}{1083}$ = ¼ mile.

Example (2):

Estimated progress of paving—70 ft. per hour.

Maximum water pressure in pump—500 lb. per sq. in.

Maximum distance water must be froced = 2½ miles.

What size pipe is required?

500 lb. = total water pressure available, which corresponds to 1,152 ft. head.

2-in. pipe under these conditions required 2,708 ft. head or 1,175 lb. pressure and is too small.

2½-in. pipe is necessary and requires, 1,116 ft. head, which corresponds to 484 lb. pressure.

A 3-in. pipe requires 377 ft. head which corresponds to 163 lb. pump pressure.

Example (3):

Estimated progress per hour = 90 ft.

Distance water must be forced = 2½ miles. What horsepower and pressure are required?

2-in. pipe requires 4,333 ft. head by table or 1,880 lb. pressure.

Water required = 7,200 gal. per hr. = 2 gal. per sec. = 16.7 lb. per second.

16.7 by 4,333 = 72,360 ft. lb. per sec. ÷ 550 = 132 horsepower.

2½-in. pipe would require 1,785 ft. head by table or 775 lb. pressure.

16.7 by 604 ÷ 550 = 18 horsepower.

3-in. pipe would require 604 ft. head by table or 250 lb. pressure.

16.7 by 604 ÷ 550 = 18 horsepower.

Water Supply Data

Loss of Head Due to Friction in Steel Pipes

Length Paved Per Hr. Ft.	Gal. Water Required Per Hr.	V Feet Per Sec.	Length of Pipe ½ Mi.	1 Mi.	1½ Mi.	2 Mi.	2½ Mi.	3 Mi.
2-inch Pipe								
...	2000	3.188	79	158	237	316	395	474
...	2400	3.825	111	222	333	444	556	667
...	2800	4.463	148	296	445	593	741	889
...	3200	5.100	190	381	571	761	952	1142
...	3600	5.738	237	474	711	948	1186	1423
50	4000	6.37	288	577	866	1155	1444	1732
60	4800	7.65	406	812	1218	1624	2030	2436
70	5600	8.92	542	1083	1625	2167	2708	3250
80	6400	10.20	695	1391	2086	2781	3477	4172
90	7200	11.47	867	1733	2600	3466	4333	5200
100	8000	12.75	1055	2111	3166	4221	5277	6332
2½-inch Pipe								
...	2000	2.233	33	65	98	130	163	195
...	2400	2.679	46	91	137	183	229	274
...	2800	3.126	61	122	183	244	305	366
...	3200	3.572	78	157	235	313	392	470
...	3600	4.019	98	195	293	390	488	586
50	4000	4.47	119	238	357	476	595	714
60	4800	5.36	167	335	502	669	836	1004
70	5600	6.25	223	446	669	893	1116	1339
80	6400	7.15	286	573	859	1146	1432	1719
90	7200	8.04	357	714	1071	1428	1785	2142
100	8000	8.93	435	870	1304	1739	2174	2609
3-inch Pipe								
...	2000	1.448	11	22	33	44	55	66
...	2400	1.737	16	31	47	62	78	93
...	2800	2.027	21	41	62	83	104	124
...	3200	2.316	27	53	80	106	133	159
...	3600	2.606	33	66	99	132	166	199
50	4000	2.89	40	80	121	161	201	241
60	4800	3.47	57	113	170	226	283	339
70	5600	4.05	75	151	226	302	377	453
80	6400	4.63	97	194	291	388	485	581
90	7200	5.21	121	242	362	483	604	725
100	8000	5.79	147	294	441	588	736	882

A 2-in. pipe = 2.067 internal diam. The formula used is the Hazen-Williams Formula.

A 2½-in. pipe = 2.469 internal diam.

A 3 -in. pipe = 3.068 internal diam.

$H = K\frac{l}{d^{1.25}v^{1.87}}$, in which

H = loss of head due to friction.

K = .00038.

l = length of pipe in feet.

v = velocity of water in feet per second.

d = diameter of pipe in feet.

Water Pressure and Heads

The head of water in feet multiplied by 0.4335 gives the pressure in pounds per square inch.

Highway Guards

While our highways still present numberless unguarded danger spots, recent years have brought a great improvement in matters of protection, and the demand for safety provisions grows. Minimum damage to cars and minimum danger to occupants are the prime and obvious objectives of any guard rail: secondarily, but still important, is a design which will not itself be too easily destroyed or damaged. Fortunately these requirements are compatible. A third quality is freedom from rust and rot. Visibility is of obvious importance.

The earlier guard rails were wood, then came cable and woven wire. Ordinary cable was used at first but later the manufacturers of wire rope developed special cables intended primarily for highway guard purposes. These cables all provide yielding barriers which diminish the shock to vehicles striking them. Numerous special fittings have been devised for attaching them to posts, anchoring them, and providing added resistance. There are usually two cables to a guard.

In addition to the earlier established types, there are now in the field many ingenious and effective patented designs, some of which are described briefly in the following paragraphs. Some of these are the result of very careful and thoroughgoing tests. They are of two principal types: the yielding, or elastic barrier, and the deflector type which turns the vehicle back onto the roadway and gives the driver a chance to regain control. Special fittings for cable guards are also included in the descriptions.

Ramsey Fittings

A device for adjustably securing the cables to the anchor rods at the ends of spans. A sleeve or quill is internally threaded at its lower end to receive the threaded upper end of an anchor rod. A circular external flange on the upper end of the sleeve is freely held within a recess in a frame. The frame has a semi-circular inner surface for free engagement with the looped end of the guard rail cable. A hex-shaped section is cast on the sleeve so that it may be turned with a wrench upon the threads of the anchor rod and thus tighten or loosen both the upper and lower cables simultaneously without rotating the frame. The device equalizes the strain of a collision upon both cables. Other items in the line include malleable iron guard rail posts, off-set brackets, turnbuckles, cable splices, anchors anchor rods, etc.

These devices are made by Joseph R. Ramsey, 11 North Pearl St., Albany, N. Y.

Melleable Iron Fittings

Fittings designed to permit a free-running cable on an off-set construction, thereby transmitting impact stress to the anchorage instead of concentrating it on from two to four posts; and spring anchorage units compensating automatically for the expansion and contraction of cables with temperature changes are manufactured by the Malleable Iron Fittings Co., Branford, Connecticut. Various assemblies are provided for deadening cables separately on posts, or for terminating both cables jointly in a yoke on anchor rod, with or without take-up feature, and with or without the special compensating spring feature. Plain socket anchorage and double turnbuckles are provided. These and other fittings, are made by the same manufacturer for ¾ in. cables of 13,000 pounds to 15,000 pounds rating, also for 20,000 pounds rating in the ¾ in. size and 30,000 pounds rating in the 1 in. size. These fittings, when tested, show a 20 per cent or greater margin of strength over the cable ratings.

Tuthill Guard

The guard rail is placed at the proper height to receive the impact from bumpers, hub caps, wheels, or running boards, thereby eliminating damage to the car body or fenders.

The design consists of the usual anchoring posts with a special ¼ in. by 10 in. spring steel, convex shaped, rail guard, mounted securely with ½ in. bolts to a 7/16 by 4 in. tempered spring steel support, especially designed. This supporting spring is bolted to the base, the strongest part of the post. In some instances a steel cable is used at the top of the post as additional precaution, although this is not essential to make the rail guard serve its purpose of preventing damage to the car by deflecting it back on the highway.

Curved end plates afford protection for vehicles striking the end of the guard rail section. This rail exhibits a conspicuous, broad, white band to day or night drivers.

Tuthill Spring Company, 760 Polk St., Chicago, is the manufacturer.

Page Traffic Tape

There are 21 parallel wires running continuously throughout this tape—the same number and same size wires as used in ¾ in. highway cable, but stronger because of the elimination of helical twist. Vehicles stop gradually and with reduced damage because tape is flexible in a horizontal plane. Strong off-set fittings reduce danger of broken posts by direct contact with vehicles. The tape is hot-galvanized, and presents a wide, silvery surface readily visible by day or night. It need not be painted, though painting will increase visibility. Sag is reduced because the tape is rigid in a vertical plane. It can be stretched on existing posts, either round or square, without change.

Page Steel and Wire Co., Monessen, Pa., manufacturers.

Pottstown Post and Springs

A post for highway guard installations consisting of a rolled steel H section to which is attached a steel spring by means of two U-bolts, constitutes the distinctive feature of this guard.

The cables pass through loops on ends of the springs and are free in the loops. The heavy spring is claimed to not only hold the cables well away from the post but also to cushion the force of the blow thus protecting both vehicle and fence.

It is claimed that the flat surfaces offered by the rolled steel H section provide greater resistance to the ground than a round post, and this feature together with the much greater strength permits a wider spacing and consequently reduces the initial cost.

Pottstown Metal Products Co., Pottstown, Pa., are the makers.

Pittsburgh Guard

This highway guard is a wire band woven under tension from spring steel wire of high tensile strength, with an elastic limit equal to approximately 95 per cent of its ultimate strength. The guard demonstrates under test a total breaking strength of more than 50 tons. The design of the fabric produces sufficient resilience to absorb and distribute shocks from impact. The continuous longitudinal wires enable the band to develop the full tensile strength of 200,000 lbs. per sq. inch of steel. High visibility also contributes to the prevention of accidents.

Made by Pittsburgh Steel Co., Union Trust Building, Pittsburgh, Pa.

Duraguard

"Duraguard" is a resilient construction designed to withstand a severe shock by absorbing the initial blow of a vehicle and then deflecting it to a position parallel to the construction so that its momentum may be checked easily.

Two types of brackets are used: a rigid type especially adaptable to rigid steel uprights on bridges and viaducts, and a cushion bracket adaptable to all general guard rail use.

The plates are steel, 12 in. wide, with reinforced end connections fitting either the rigid or the cushion bracket type as well as with end post and bridge end connections. All sheets are true, and so fabricated that they will take care of expansion and contraction as well as serve to keep the entire section of guard rail in tension at all times. Plates are furnished galvanized or painted.

Unless otherwise specified all sections are standard lengths: intermediate sections, 15 ft. 11¾ in., and end sections 7 ft. 6 in. These sections require post spacings 16 ft. on center except the end sections which are 8 ft. on center. Lengths to meet special conditions are available.

This guard is made by Truscon Steel Co., Youngstown, Ohio.

Resiliflex Guard Rail

The following features are embodied in the "Resiliflex Guard Rail," made by the National Traffic Guard Company, 215 Moreland Ave., N. E., Atlanta, Ga., 120 South La Salle St., Chicago, and 237 Fourth Ave., Pittsburgh, Pa.

Steel rail plates have tensile strength of not less than 60,000 pounds, and are connected through resilient members which distribute forces to numbers of posts on either side of contact. Supports consist of heavy interlocking steel springs. Rail is off-set approximately 6 in. from posts by resilient members. Surface of rail is smooth, allowing vehicles to slide along, instead of bringing to an abrupt stop. Rail is at hub and wheel height, receiving impact from those portions of vehicles best suited to withstand the severe strains. Rail members are interlocked at joints, making a continuous structure even in event of post or bracket failure. Any unit can be repaired or replaced without disturbing the structure as a whole. The structure has a solid surface 12 in. wide exposed to the roadway, and when painted white is highly visible.

Wood Guard Rail

Specifications, Vermont State Highway Department

Description.—The railing shall consist of wood rails supported by wood posts erected where indicated on the Plans or directed by the Engineer in accordance with these Specifications.

Material.—The posts shall be of seasoned white oak, cedar, locust or tamarack. Posts and rails shall be sound and cut from live timber. The posts shall be eight (8) inches square, or if round, shall be ten (10) inches in diameter at the smaller end after the bark is removed and six (6) feet long. Round posts shall be shaved to even surface, free from bark or skin. The rail shall be seasoned spruce or other satisfactory wood planed on four (4) sides and of the dimensions as shown on the Plans and be properly secured to the posts, all in a workmanlike manner.

Paint.—The white paint for painting the fence after erection shall be composed of from sixty-five (65) to seventy (70) per cent, by weight, of pigment in paste form and from thirty-five (35) to thirty (30) per cent of vehicle; or sixty (60) to sixty-five (65) per cent, by weight, of dry pigment.

(a) Pigment. The pigment shall be composed of not less than sixty-five (65) per cent of pure white lead and not less than twenty (20) per cent of pure zinc white, all finely ground. Not more than fifteen (15) per cent of inerts shall be permitted.

(b) Vehicle. The vehicle shall be composed of not less than ninety (90) per cent of pure raw linseed oil and sufficient first quality Japan or other approved drier free from rosin to cause the applied paint to dry in approximately three (3) days, but in no case shall the drier exceed ten (10) per cent.

(c) Black Paint. Black paint for painting on the posts shall meet one of the two requirements given below. Black paint shall be used for painting the guard rail posts from the ground line to the lower rail.

(1) The guard rail black paint shall be homogeneous, free from water, and shall dry hard in twenty (20) hours with a jet black color and shall meet the following requirements:

A. Specific gravity at 25/25° C. not less than... 1.10
B. Specific Viscosity (Engler) at 40° C..... 5-8
C. Distillation—% by weight
0—170° C..... 2-14
0—270° C..... 26-30
0—300° C..... 32-36
D. Total bitumen soluble in CS_2 not less than 95%.

(2) This paint shall be composed of pure graphite mixed with pure raw linseed oil and suitable drier. The pigment shall contain not less than seventy (70) per cent total graphite carbon. The vehicle shall consist of not less than ninety (90) per cent of pure raw linseed oil mixed with enough drier free from rosin to cause the paint to dry properly. The linseed oil shall comply with the requirements of the "Standard Specifications for Purity of Raw Linseed Oil from North American Seed" of the American Society for Testing Materials as given in the A. S. T. M. Standards, 1918, Serial Designation D1-15. The paint, when ready for application, shall contain not less than thirty (30) per cent of pigment by weight. The paint pigment shall contain not more than five (5) per cent of calcium carbonate or calcium sulphate.

Preservative Treatment.—All guard rail posts shall be given a preservative treatment from the bottom to six (6) inches above the ground line in accordance with the following specifications:

Posts to be treated must be seasoned air dry (Moisture content shall not exceed twenty (20) per cent of the average oven-dry weight of the respective species).

Special care shall be exercised to see that the portion treated is free from all inner and outer bark. When necessary, this portion of posts shall be shaved with a draw knife.

Posts shall be immersed to a point six (6) inches above the ground line in:

(a) Hot bath of preservative material maintained at a temperature of approximately 200° F. for one (1) hour.

(b) Immediately after (a), transfer to cold bath of preservative material to be maintained at atmospheric temperature within the minimum and maximum limits of 50° F. and 100° F., wherein posts are likewise to be immersed for one (1) hour.

The specified time of one (1) hour for hot bath and cold bath shall be decreased or increased by the Engineer

to obtain results that will secure as deep a penetration of the preservative material as possible but with a minimum amount of oil.

The preservative material shall be a liquid grade of pure coal-tar creosote oil, specially refined for non-pressure treatments and conforming to the following requirements:

The oil must be a pure distillate from coal-tar.

It shall be liquid at 50° C. (41° F.).

The specific gravity at 15° C. shall be at least 1.06.

Water must not exceed one (1) per cent.

The matter insoluble in hot benzol shall not exceed five-tenths (0.5) per cent.

Upon distilling by the Standard Am. Ry. Eng. Assoc. method, the oil on a dry basis must give:

(a) Not more than one (1) per cent up to 210° C.

(b) Not more than ten (10) per cent up to 235° C.

(c) Not less than twenty-five (25) per cent nor more than sixty (60) per cent up to 300° C.

Construction Methods.—The guard rail shall be constructed in accordance with the standard plan. The posts shall be set vertical to full depth and spaced as shown on the plans and accurately lined and relined when necessary. The post holes shall be backfilled with suitable material and thoroughly tamped in layers of not more than six (6) inches, care being taken to preserve the alignment of the posts. All joints of the rail shall be painted before being fastened together. Any portion of the post showing creosote over six (6) inches above the ground line shall be coated with shellac before painting. After satisfactory erection the rail and posts, when dry, shall be painted in an approved manner with two (2) coats of the specified material.

No painting will be allowed when the air temperature is 40° F. or below, and painting will not be permitted unless the rail and posts are thoroughly dry. After the first coat of paint has been applied at least three (3) days shall elapse before the application of the second coat of paint.

Method of Measurement.—The length of Wood Guard Rail under this item shall be the number of linear feet erected, complete in place, and measurements shall be from outer post to outer post only.

Basis of Payment.—This work shall be paid for at the contract unit price per linear foot for Wood Guard Rail, complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto; also all excavation, refilling and disposal of surplus material.

Cable Guard Rail

Specifications, Vermont State Highway Department

Description.—Cable Guard Rail shall consist of wire Cable, supported by wood posts erected as indicated on the Plans or as directed by the Engineer, in accordance with the Specifications.

Material.—(a) Wood Posts. The posts shall be of seasoned white oak, cedar, locust or tamarack and shall be sound and cut from live timber. The posts shall be not less than six (6) inches in diameter at the smaller end after the bark is removed and seven (7) feet long. The posts shall be shaved to even surface, free from bark or skin. All posts shall be given the preservative treatment as specified under Wood Guard Rail.

(b) Wire Rope. The rope shall be manufactured of double galvanized annealed steel having the properties hereinafter required.

The rope shall be composed of three (3) strands, each strand having seven (7) wires. The diameter of the finished rope shall not be less than three-quarters (¾) inch. The wires composing the rope shall be of such quality that the finished rope shall satisfy all the requirements hereinafter set forth. All of the wires in the rope shall be of the same grade steel and shall have approximately the same breaking strain.

The lay of the finished rope shall not be more than seven and one-half (7½) inches. The lay of the wires in the strand shall not be more than four and one-half (4½) inches.

The diameter of the finished wires entering into the rope shall not be less than one hundred seventeen thousandths (.117) inch and not more than one hundred twenty-four (.124) inch.

The minimum tensile strength of the rope shall be twenty thousand (20,000) pounds.

The wire shall be cylindrical in form and be free from scales, inequalities, flaws and splits.

Each wire from the rope shall be galvanized by the Hot Dip Method and shall have a continuous coating of pure zinc of a uniform thickness, so applied that it will adhere firmly to the surface of the wire, and it shall be capable of withstanding four (4) immersions in a standard testing solution of copper sulphate without showing any trace of metallic copper on the steel. The first three (3) immersions shall be for a period of one (1) minute each and the fourth immersion for a period of one-half (½) minute.

If heavier wire rope is to be used, the number of strands, the number of wires per strand, the diameter of the finished rope, the lay of the finished rope and the lay of the wires in the strands shall be as required by the Engineer.

All wire rope must be shipped upon substantial wooden reels. Each reel shall have the length and weight of the rope plainly and indelibly marked on a strong tag, firmly attached. The wooden reel shall be mounted so that it will revolve and the rope run off by pulling straight ahead.

(c) Anchors. Anchors for all end posts shall consist of concrete deadmen of the design and dimensions shown on the drawings or of other design approved by the Engineer.

(d) Fittings. All fittings shall be of the design and dimensions shown on the drawings or as approved by the Engineer and shall be galvanized or sherardized. All end fittings shall be of a design and type that will develope a tensile strength of not less than twenty thousand (20,000) pounds per cable when properly installed.

(e) Paint. The material for and method of painting the posts after erection shall conform to the requirements as specified under Wood Guard Rail.

Construction Methods.—The guard rail shall be constructed in accordance with the standard plan. The posts shall be set vertical to full depth and spaced as shown on the Plans and accurately lined and relined when necessary. The post holes shall be back-filled with suitable material and thoroughly tamped in layers of not more than six (6) inches, care being taken to preserve the alignment of the posts. The wire rope shall be fastened to the posts by galvanized hook bolts. The ropes shall be drawn taut and fastened securely to the anchors as shown on the standard plans. On sections of rail of more than five hundred (500) feet in length, extra anchors shall be placed in accordance with the Plans so that the rail will be anchored both ways, giving anchored lengths of five hundred (500) feet or less. Extra anchors and fittings shall be furnished as required. Splicing of the cable will not be permitted. After erection is completed, the wood posts shall be painted as required under Wood Guard Rail.

Method of Measurement.—The length of Cable Guard Rail under this item shall be the number of linear feet erected, complete in place, and measurements shall be from outer post to outer post to which cable is attached and will not include the distance between the end post to which cable is attached and the anchor.

The number of anchorages for cable guard rail under this item shall be the number of anchorages with fittings as constructed in accordance with the Plans and these Specifications.

Basis of Payment.—The Cable Guard Rail shall be paid for at the contract unit price per linear foot for Cable Guard Rail, complete in place, which price shall include all materials, equipments, tools, posts, excavation, backfilling and all work incidental thereto, except the construction of anchorages.

Anchorages for Cable Guard Rail shall be paid for at the contract unit price each for anchorages for Cable Guard Rail, complete in place, which price shall include all dummy posts, materials, equipment, tools, excavation, backfilling and all work incidental thereto.

Wire Guard Fabric

Specifications, Illinois Division of Highways

Description.—These specifications cover zinc-coated chain-link guard fabric in which the individual pickets are helically wound and interwoven in the form of a continuous fabric without knots or ties.

Materials.—The materials used in the fabrication of the chain-link guard fabric shall comply with the following requirements:

(a) *Wire.*—Before fabrication or galvanizing, the base metal composing the wire shall conform to the requirements of the "Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement, A. S. T. M. Designation: A 82-27," except that the wire shall have a minimum tensile strength of seventy thousand (70,000) pounds per square inch and that the number of tension tests made for each ten (10) tons or less of wire shall be optional with the Department.

If copper bearing base metal is used, the copper content shall not be less than two-tenths (0.2) of one (1) per cent.

(b) *Spelter.*—The spelter used for the coating shall be any grade of spelter conforming to the requirements of the "Standard Specifications for Slab Zinc (Spelter), A. S. T. M. Designation: B 6-18."

Sampling and Testing.—The wire and spelter shall be sampled before the fabricating operations are started. The base metal composing the wire shall be sampled and tested in accordance with the requirements of the "Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement, A. S. T. M. Designation: A 82-27," except as herein provided.

The weight of spelter coating shall be determined in accordance with the "Methods of Determining Weight of Coating on Zinc-Coated Articles, Tentative Method T-65," and the uniformity of coating in accordance with the "Method of Test for Uniformity of Galvanizing or Spelter Coating on Wire, Tentative Method T-66," of the A. A. S. H. O. The coating shall withstand not less than six (6) one-minute dips in the standard Preece test solution.

As many samples of the completed fabric may be taken by the Department as is considered necessary. Each sample shall be one (1) foot wide. All samples shall be furnished to the Department free of charge.

When field tests are required to determine the tensile strength of wire after fabrication, pickets shall be selected at random and unwoven without cutting. When pickets thus selected are straightened and tested, they shall conform to the requirements given herein for the wire before fabrication.

(a) *Rejection.*—Failure of the completed fabric to meet any one or more of the following requirements will be considered sufficient cause for rejection:

(1) Insufficient weight of spelter coating.

(2) Nonuniformity of spelter coating as shown by the Preece test.

(3) Imperfections in the spelter coating as enumerated under "Size and Construction."

(4) Spelter coating which has cracked, peeled or flaked during shipment or during erection.

(5) Nonuniformity of weaving, such as a variation in the radius of the bends in the pickets, or in the dimensions of the meshes.

(6) Fabric in which the pickets have become embrittled or otherwise injured or damaged by the pickling or galvanizing process.

(7) Fabric which has been injured or damaged by the method of handling at the plant or by careless handling.

(8) The approval of the wire, or of the spelter, or of the fabricated wire before galvanizing, shall not in any way obligate or bind the Department to accept the finished fabric if it shows injurious defects subsequent to fabrication.

Size and Construction.—The width of the fabric shall be twenty-four (24) inches. The wire shall be woven either: (1) in the form of approximately uniform square mesh, two (2) inches by two (2) inches, having parallel sides and horizontal and vertical diagonals of approximately uniform dimensions; or, (2) in an approximately uniform diamond mesh having horizontal and vertical diagonals of approximately six (6) inches by three (3) inches. If of the type specified in (1) above, the wire used shall be steel wire gauge No. 6 (diameter 0.192 inches); if of the type specified in (2) above, the wire used shall be steel wire gauge No. 4 (diameter 0.2253 inches).

The top and bottom ends of each pair of pickets shall be turned back over each other to form a knuckle, and the knuckles shall be closed.

All fabric shall be galvanized after weaving. The weight of the spelter coating shall be not less than one and two-tenths (1.2) ounces per square foot of wire surface. The coating shall be smooth, shall have no rough spots, frozen joints, abrasions, blisters, air-holes, or other objectionable imperfections which might impair its rust-resisting properties, and shall be of such quality that it will not crack, peel or flake during shipment or erection.

The completed fabric shall be prepared for shipment in rolls of one hundred (100) lineal feet each. In measuring the amount of fabric in each roll the fabric shall not be placed under tension. Each roll of fabric shall be tightly rolled and firmly tied.

Placing Wire Guard Fabric

Specifications, Illinois Division of Highways

The fabric shall be placed as shown on the plans, drawn taut, and stapled to the front side of each post with three (3) galvanized staples one and one-half (1½) inches in length. The edges of the fabric shall be parallel with the grade line and at the required height above the shoulder. On curves of five (5) degrees and greater, strips of twenty-four (24) gauge galvanized metal, six (6) inches wide shall be fastened securely to the top and bottom of the fabric.

About 45,000,000 gallons of road oil are used annually on the 10,000 miles of earth roads in Illinois.

Timber Highway Bridges and Structures

Specifications American Association of State Highway Officials

Construction

Grading of Lumber and Timber.—Yard lumber and structural timber shall be graded in accordance with grading rules, adopted by the regional associations of lumber manufacurers, which conform to the basic provisions of "American Lumber Standards."

Lumber ordered in multiple lengths shall be graded after being cut to length.

Structural Shapes.—Rods, plates and shapes shall be of structural steel or wrought-iron as specified. Eyebars shall conform to the requirements for structural steel eyebars.

Castings.—Castings shall be cast steel or gray-iron as specified.

Hardware.—Machine bolts, drift bolts and dowels may be either wrought-iron or medium steel. Washers may be cast ogee or malleable castings, or may be cut from medium steel or wrought-iron plate, as specified.

Machine bolts shall have square heads and nuts unless otherwise specified. Nails shall be cut of round wire of standard form. Spikes shall be cut of wire spikes, or boat spikes, as specified.

Nails, spikes, bolts, dowels, washers and lag screws shall be black or galvanized, as specified.

Storage of Material.—Lumber and timber on the site of the work shall be stored in piles.

Untreated material shall be open-stacked at least 12 inches above the ground surface, and piled to shed water and prevent warping. When required by the engineer it shall be protected from the weather by suitable covering.

Creosoted timber and piling shall be close stacked, piled to prevent warping, and the tops of the stacks shall be covered with a 2-inch layer of earth.

The ground underneath and in the vicinity of all material piles shall be cleared of weeds and rubbish.

Workmanship.—Workmanship shall be first class throughout. None but competent bridge carpenters shall be employed and all framing shall be true and exact. Nails and spikes shall be driven with just sufficient force to set the heads flush with the surface of the wood. Deep hammer marks in wood surfaces shall be considered evidence of poor workmanship and sufficient cause for the removal of the workman causing them. The workmanship on all metal parts shall conform to the requirements specified for Steel Structures.

Treated Timber.—Handling. Treated timber shall be carefully handled without sudden dropping, breaking of outer fibers, bruising or penetrating the surface with tools. It shall be handled with rope-slings. Cant dogs, peaveys, hooks or pike-poles shall not be used.

Framing and Boring. All cutting, framing and boring of treated timbers shall be done before treatment in so far as is practicable. In waters infested by marine borers, cutting and boring below high water shall be avoided.

Cuts and Abrasions. All cuts in treated piles or timbers, and all abrasions after having been carefully trimmed, shall be covered with two applications of a mixture of 60 per cent creosote oil and 40 per cent roofing pitch or brush coated with at least two applications of hot creosote oil and covered with hot roofing pitch.

Bolt Holes. Before driving bolts, hot creosote oil shall be poured into all bolt holes in such a manner that the entire surface of the hole shall be thoroughly coated with the oil. Any unfilled holes, after being treated with creosote oil, shall be plugged with creosoted plugs.

Untreated Timber.—In structures of untreated timber the following surfaces shall be thoroughly coated with hot creosote oil before assembling; Ends, tops and all contact surfaces of sills, caps, floor-beams and stringers; and all ends, joints, and contact surfaces of bracing and truss members. The back faces of bulkheads and all other timber which is to be in contact with earth shall be similarly treated.

Bolts passing through non-resinous wood shall preferably be galvanized.

Timber Piles.—Quality: All wood piling shall be cut from sound and solid trees, preferably during the winter season. They shall contain no unsound knots. Sound knots will be permitted provided the diameter of the knot does not exceed 4 inches or one-third of the diameter of the stick at the point where it occurs. Any defect or combination of defects which will impair the strength of the pile more than the maximum allowable knot shall not be permitted. The butts shall be sawed square and the tips shall be sawed square or tapered to a point not less than 4 inches in diameter as directed by the engineer.

Unless otherwise specified, all piles shall be peeled by removing all of the rough bark and at least 80 per cent of the inner bark. No strip of inner bark remaining on the stick shall be over ¾ inch wide or over 8 inches long, and there shall be at least 1 inch of clean wood surface between any two such strips. Not less than 80 per cent of the surface on any circumference shall be clean wood.

Piles shall be cut above the ground swell and shall taper from butt to tip. A line drawn from the center of the tip to the center of the butt shall not fall outside of the center of the pile at any point more than 1 per cent of the length of the pile. In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed 4 per cent of the length of the bend or 2½ inches. All knots shall be trimmed close to the body of the pile.

Dimensions: Round piles shall have a minimum diameter at the tip, measured under the bark, as follows:

Length of pile	Tip Diameter
Less than 40 feet	8 inches
40 to 60 feet	7 inches
Over 60 feet	6 inches

The minimum diameter of piles at a section 4 feet from the butt, measured under the bark, shall be as follows:

	Diameter in inches	
Length of pile	Douglas Fir, Southern Yellow Pine, Southern Cypress	All other species
20 feet and under	11	11
20 to 30 feet	12	12
30 to 40 feet	12	13
Over 40 feet	13	14

The diameter of the pile at the butt shall not exceed 20 inches. Square piles shall have the dimensions shown on the plans.

Treatment of Pile Heads.—After having been cut to receive the caps, and prior to placing the caps, pile heads shall be treated to prevent decay.

The heads of creosoted piles shall be treated as follows:

The sawed surface shall be covered with three applications of a mixture of 60 per cent creosote oil and 40 per cent roofing pitch or thoroughly brush coated with three applications of hot creosote oil and covered with hot roofing pitch. Upon this shall be placed a covering of medium-weight roofing felt or galvanized iron which shall be bent down over the sides of the pile to shed water.

The heads of untreated piles shall be given one of the following treatments as may be specified or directed by the engineer:

1. The sawed surface shall be thoroughly brush coated with two applications of hot creosote oil.

2. The sawed surface shall be heavily coated with red lead paint, after which it shall be covered with cotton duck, of at least 8-ounce weight, which shall be folded down over the sides of the pile and firmly secured thereto with large-headed roofing nails. The edges of the duck shall be trimmed to give a workmanlike appearance. The duck shall then be waterproofed by being thoroughly saturated and coated with one or more applications of red lead paint.

Bolts, Dowels, Rods and Lag Screws.—Holes for round drift bolts and dowels shall be bored with a bit 1/16 inch less in diameter than the bolt or dowel to be used. The diameter of holes for square drift bolts or dowels shall be equal to the least dimension of the bolt or dowel.

Holes for machine bolts shall be bored with a bit of the same diameter as the bolt.

Holes for rods shall be bored with a bit 1/16 inch greater in diameter than the rod.

Holes for lag screws shall be bored with a bit not larger than the body of the screw at the base of the thread.

Bolts and Washers.—A washer, of the size and type specified, shall be used under all bolt heads and nuts which would otherwise come in contact with wood.

All bolts shall be effectually checked after the nuts have been finally tightened.

Countersinking.—Countersinking shall be done wherever smooth faces are required. Recesses formed for countersinking shall be painted with hot creosote oil, and after the bolt or screw is in place, shall be filled with hot pitch.

Framing.—All lumber and timber shall be accurately cut and framed to a close fit in such a manner that the joints will have even bearing over the entire contact surfaces. Mortises shall be true to size for their full depth and tenons shall make snug fit therein. No shimming will be permitted in making joints, nor will open joints be accepted.

Pile Bents.—The piles shall be driven as accurately as possible in the correct location and to the vertical or batter lines indicated on the plans. In case a pile is driven out of line, it shall be straightened without injury before it is cut off or braced. Piles damaged in driving or straightening, piles driven below grade, shall be removed and replaced at the contractor's expense. No shimming on tops of piles will be permitted.

The piles for any one bent shall be carefully selected as to size to avoid undue bending or distortion of the sway bracing.

Cut-offs shall be accurately made to insure perfect bearing between the cap and piles of a bent.

Framed Bents.—Mud Sills. Untreated timber used for mud sills shall be of cedar, heart cypress, redwood or other durable timber. Mud sills shall be firmly and evenly bedded to solid bearing and tamped in place.

Concrete Pedestals. Concrete pedestals for the support of framed bents shall be carefully finished so that the sills or posts will take even bearing on them. Dowels of not less than ¾-inch diameter and projecting at least 6 inches above the tops of the pedestals, shall be set in them when they are cast, for anchoring the sills or posts.

Sills. Sills shall have true and even bearing on mud sills, piles or pedestals. They shall be drift bolted to mud sills or piles with bolts of not less than ¾-inch diameter and extending into the mud sills or piles at least 6 inches. When possible all earth shall be removed from contact with sills so that there will be free air circulating around them.

Posts. Posts shall be fastened to pedestals with dowels of not less than ¾-inch diameter extending at least 6 inches into the posts.

Posts shall be fastened to sills by one of the following methods, as indicated on the plans:

(a) By dowels of not less than ¾-inch diameter extending at least 6 inches into posts and sills.

(b) By drift bolts of not less than ¾-inch diameter driven diagonally through the base of the post and extending at least 9 inches into the sill.

Caps.—Timber caps shall be placed to secure an even and uniform bearing over the tops of the supporting posts or piles and to secure an even alignment of their ends. All caps shall be secured by drift bolts of not less than ¾-inch diameter extending at least 9 inches into the posts or piles. The drift bolts shall be approximately in the center of the post or pile.

Bracing.—The ends of bracing shall be bolted through the pile, post or cap with a bolt of not less than ⅝-inch diameter. Intermediate intersections shall be bolted, or spiked with wire or boat spikes, as indicated on the plans. In all cases spikes shall be used in addition to bolts.

Stringers.—Stringers shall be sized at bearings and shall be placed in postion so that knots near edges will be in the top portions of the stringers.

Outside stringers may have butt joints but interior stringers shall be lapped to take bearing over the full width of floor beam or cap at each end. The lapped ends of untreated stringers shall be separated at least ½ inch for the circulation of air and shall be securely fastened by drift-bolting where specified. When stringers are two panels in length the joints shall be staggered.

Cross bridging between stringers shall be neatly and accurately framed and securely toe-nailed with at least two nails in each end.

Wheel Guards and Railings.—Wheel guards and railing shall be accurately framed in accordance with the plans and erected true to line and grade.

Unless otherwise specified, wheel guards shall be surfaced one side and one edge (S1S1E) and rails and rail posts shall be surfaced on four sides (S4S).

Wheel guards shall be laid in sections not less than 12 feet long.

Horizontal Shear in Beams.—Horizontal shear in beams shall be computed from the maximum shear occurring at a distance from the support equal to three times the depth of the beam.

Pressure Treatments

Timber and piling are protected from decay by pressure treatment wtih creosote, and for treatment either the full-cell or empty-cell processes may be specified. The final retention of the preservative per cubic foot of wood, *i. e.,* the quantity of preservative to be left in the wood at the conclusion of the treating operation—should be stipulated.

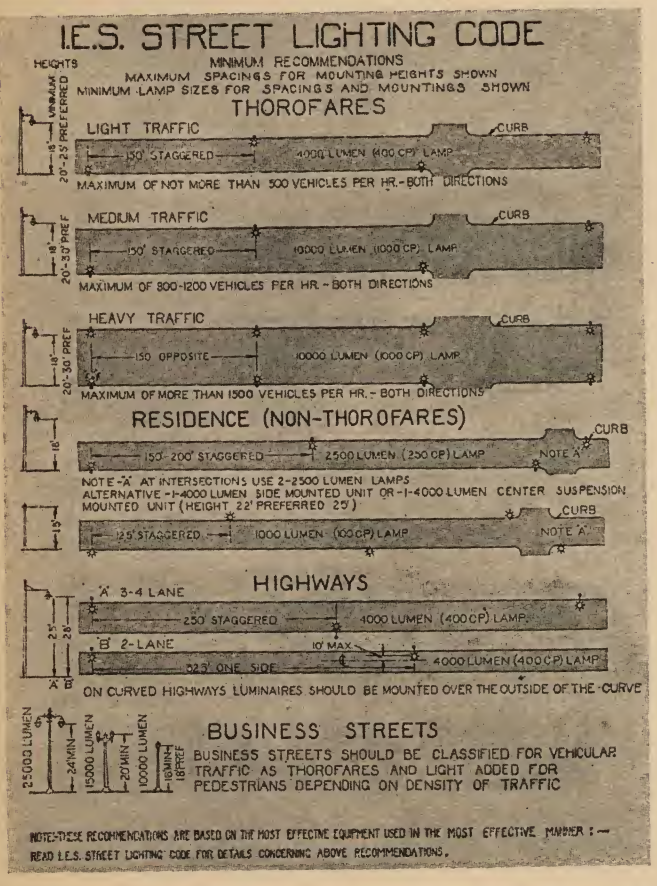
For southern pine bridge timber and piling a 12-lb. treatment by empty-cell process is common, while for Douglas fir an 8- or 10-lb. retention of preservative when treated by empty-cell process or a 12-lb. retention when treated by full-cell process is usual. Creosote should be *Grade One* conforming to standard specifications. Complete specifications for the preservative and for the several steps of the treating processes are published by the American Wood-Preservers' Association, Chandler Bldg., Washington, D. C., and are identical with those in the Standard Specifications for Highway Bridges and Incidental Structures of the American Association of State Highway Officials.

Recommendations for Street and Highway Lighting — I. E. S. Code

The following recommendations are condensed from a paper by Alexander Anderson, New York Power & Light Corporation, Albany, presented at the 12th annual conference of the International Association of Public Works Officials, and abstracted in ROADS & STREETS for February, 1932:

A committee of the Illuminating Engineering Society, composed of consulting engineers, utility men, electrical laboratories, manufacturers, street light officials of municipalities, university professors and advisory members, worked for two years preparing a minimum code for street lighting, which was adopted at the I. E. S. convention at Richmond in October, 1930. *This code was also adopted by the N. E. L. A. as their engineering standard for street lighting.

Planning.—Progressive communities are taking up the improvement of street lighting by drawing ordinances classifying the streets and specifying the kind of standards, fixtures, lamps and spacing to be used on the several classes of streets.



It is always well to standardize on the type standards to be used on the different classes of streets; the fewer the number of types used the better, which tends to improve the appearance of the streets.

In drawing an ordinance, the names of all streets in a class should be written in under that class, and a program included of the streets to be improved year by year until completed. Usually a time is set, such as a five-year period, to completely revamp the present system and carry out extensions along the lines laid down in the ordinance.

In drawing up a street lighting improvement program, the engineers will allow for 20th century high speed traffic by specifying the requisite illumination per lin. ft. of street, so that vehicular and pedestrian traffic may move with safety.

Specifications. — Following is a condensation of the principal provisions of the I. E. S. Code of 1930.

Classification of Streets. — For the purposes of the recommendations which follow, thoroughfares, streets and highways may be classified according to their type and traffic functions, as follows:

Light Traffic Thoroughfares—Residence Streets.
Medium Traffic Thoroughfares—Alleys.
Heavy Traffic Thoroughfares—Park Drives.
Business Streets—Highways.

To classify traffic, take the vehicular counts per hour of a typical week at maximum, during lighting period. On this basis the following are considered usable definitions:

Light traffic thoroughfares usually carry a maximum of not more than 500 vehicles per hour, both directions.

Medium traffic thoroughfares usually carry a maximum of approximately 800 to 1200 vehicles per hour, both directions.

Heavy traffic thoroughfares usually carry a maximum of more than 1500 vehicles per hour, both directions.

This code is a minimum for representative conditions; accordingly, as traffic density increases and streets are unusually wide, use more light.

When headlight laws are not enforced, more light is required.

With heavy pedestrian traffic, use more light.

With street car traffic, use more light.

With one way traffic, use less light.

No auto parking calls for less light.

Minimum Requirements.—The code provisions correspond to the provisions for minimum lighting in the supplementary recommendations in the tabulation following. As indicated in the table, staggered spacing is preferred in most cases, opposite spacing being limited to the busiest thoroughfares.

Street Lighting Recommendations Supplementary to I. E. S. Code of Street Lighting

Recommended Minimum Street Lighting

Type of Street	Mounting Height in Feet	Spacing in Feet	Lumens per Lamp	Lumens per Lin. St. F.
Light Traffic	18-25	1 Stag. 150	4000	27
Med. Traffic	18-30	1 Stag. 150	10000	66
Hvy. Traffic	18-30	1 Opp. 150	10000	133
Bus. Sts.	16-24	1 Opp. 150	10000	133
Res. Sts.	15-18	1 Stag. 150-200	2500	17-13
Alleys	18	1 Stag. 150-200	2500	17-13
Park Drives	18-25	1 Stag. 150-200	2500	17-13
Highways	22-28	1 Stag. 250-325	4000	16-13

Recommended Medium Street Lighting

Light Traffic	18-25	1 Stag. 150	6000-1000	40-67
Med. Traffic	18-30	1 Stag. 150	10000-15000	67-100
Hvy. Traffic	18-30	1 Opp. 150	10000-15000	133-240
Bus. Sts.	16-24	1 Opp. 100	15000-25000	300-500
Res. Sts.	15-18	1 Stag. 125-150	2500-4000	20-32-17-27
Alleys	18	1 Stag. 125-150	2500	20-17
Park Drives	18-25	1 Stag. 250	4000-6000	20-48-17-40
Highways	22-28	1 Stag. 250	4000-6000	16-24

*This code remains unchanged at the beginning of the year 1934.

Recommended Good Street Lighting

Light Traffic	18-25	1 Stag.	100	10000	100
Med. Traffic	18-30	2 Stag.	100	10000-15000	200-300
Hvy. Traffic	18-30	2 Opp.	100-125	10000-15000	400-480
Bus. Sts.	16-24	2 Opp.	80-125	15000-40000	750-2000
Res. Sts.	15-18	1 Stag.	75-125	2500-6000	33-48
Alleys	18	1 Stag.	125	2500	20
Park Drives	18-25	1 Stag.	100-125	4000-10000	40-80
Highways	22-28	1 Stag.	250-300	6000-10000	24-33

These specifications are based upon the use of equipment of the most effective type in the most effective manner. With less effective equipment or less effective application of light, larger lamps or closer spacings are required. The minimum mounting height of 18 ft. should be employed only where trees are present or other conditions make a higher mounting height impracticable.

It is recommended that luminaires be located on brackets extending out beyond the curb, except where center suspensions are used.

For given sizes of lamps the minimum mounting heights should be as follows:

	Not less than
For lamps of 25,000 lumens and over	24 ft.
For lamps of 15,000 lumens	20 ft.
For lamps of 10,000 lumens and less	16 ft.

The mounting height of center suspensions should be not less than 22 ft.—preferably not less than 25 ft.

Intersections, Alleys and Curves.—At intersections of residence streets carrying only local traffic, not less than one 4000-lumen or two 2500-lumen lamps should be installed. Alleys in business and industrial sections and the entrances, exits and intersections of public alleys in residence districts should be lighted.

On curved highways, luminaires should be mounted over the outside of the curve.

Lamp Standards and Aesthetic Considerations.—The standards should be of ornamental design for two or more pendant lamps of from 1000 to 2500 C.P., or even larger, with mounting height of 20-30 ft. and opposite. In the smaller towns single lamp ornamental standards may be used, carrying 100-1500 C.P. upright lamps, with mounting height of 16-18 ft., depending on the height of the buildings.

On residential streets, the same construction may be used as in ordinary thoroughfares, using not less than 250 C.P. lamps. Where trees are very dense and low, single lamp standards may be used with 15 ft. mounting height and upright lamps not less than 250 C.P.

Where the service is overhead in less important districts, light 4-ft. brackets with 100 C.P. pendant lamps extending beyond the curb may be used with 15-ft. mounting height, spaced not more than 125 ft.

In promoting the aesthetic qualities of the streets, I am suggesting the use of dark brown bronze paint with a yellowish tinge and high gloss. This kind of paint tends to make the lamp standards harmonize with their surroundings and blend with the usual building construction. It is not conspicuous, as it has an antique bronze appearance. It should be sprayed on for the most uniform and best results. It has been used in Albany to the satisfaction of the city engineer. Green paint was supposed to look better among trees, but the dark bronze seems to blend with the tree trunks.

Tree Trimming.—It does not matter how good the street lighting equipment is, or how well it is taken care of, if it is buried among trees so that the light cannot reach the roadway. Public utilities are not in a very good position to trim trees. In order to obtain the best results for street lighting, trees should be trimmed so that the light may reach the street surface. In some communities trees are trimmed 12 ft. above the sidewalk and 18 ft. above the roadway, which has many advantages. It makes proper lighting possible, and is more pleasant for pedestrians in wet weather, also giving trucks better head room, besides a general improvement in street appearance and tree health.

Street Light Equipment.—I would suggest to the municipalities not to tie up the utilities too tightly as to the exact kind of equipment they are to furnish, but only as to the candle power of lamps, for in these days the art of lighting is advancing so rapidly that probably long before contracts which are now being made have expired, the present lighting equipment may be out of date. This has happened in the past and, while the utilities were in a position and desired to furnish more modern equipment, they were so tied up by their contracts that they were not allowed to do so.

▼

White Traffic Zone Paint

Specifications, American Association of State Highway Officials

Tentative Standard Specification for White Traffic (Zone) Paint (Ready Mixed) for Bituminous Pavements. Specification M-34. Revised: 1933.

A. General Requirements

1. The paint shall be well ground, shall not settle badly or cake in the container, shall be readily broken up with a paddle to a smooth, uniform condition, capable of easy application with a brush in the ordinary manner according to the rules of standard practice.

2. It is required under these specifications that the color after drying shall be a white, furnishing the maximum amount of opacity and visibility. The paint shall dry sufficiently within one-half hour after application so there will be no pick-up under traffic, and thoroughly dry, free from any tackiness, within one hour after application.

B. Properties

3. *Composition.*

	Minimum per cent	Maximum per cent
Pigment	60	65
Vehicle (containing at least 40 per cent of fixing drying oils)	35	40

4. *Pigment.*

Siliceous material	30	32
Lithopone (light fast)	68	70

5. *Vehicle.*—The vehicle should consist of the best quality of fixed drying oil (properly treated tung or linseed or mixture of these two oils), gum varnish, Japan drier and volatile thinner so proportioned in order to obtain a paint of the required color, durability and drying time. The fixed drying oils shall be of such color and quality as will not darken under service to impair the paint's visibility, and shall furnish the maximum elasticity and durability.

Tentative Standard Specification for White Traffic (Zone) Paint (Ready Mixed) for Brick and Concrete Pavements. Specification M-35. Revised: 1933.

A. General Requirements

1. Paint shall be well mixed in the manufacture by proper grinding of the pigment, incorporating the inerts to meet the requirements hereafter specified. The pigment shall not settle badly or cake in the container, shall not thicken in storing to cause change in consistency, shall be readily broken up with a paddle to a smooth, uniform condition, capable of easy application with a brush or mechanical distributor in the ordinary manner according to the rules of good standard practice.

2. It is required under these specifications that the paint after drying shall have a pebbly or roughened sur-

face and that the color shall be a *flat* white, furnishing the maximum amount of opacity and required amount of visibility for both night and day conditions of service. The night visibility of the reflected paint as measured by an Illuminometer in photometric apparatus* at an angle of incidence of 88 degrees 20 minutes with an angle of reflection of 87 degrees 8 minutes, shall be at least ten foot-candles when compared to a ground standard milk glass plate having an angle of diffuse reflection of approximately 77 per cent and furnishing an Illuminometer reading of three foot-candles.

3. Paints submitted of required composition as hereinafter specified will be rated on the basis of unit price, the best night and day visibility, ease of application, covering and compliance with other requirements of specifications as determined by the Engineer. The paint shall dry sufficiently within one-half hour after application so there will be no pick-up under traffic, and thoroughly dry, free from any tackiness, within one hour after application.

B. Properties

4. *Composition.*

	Minimum per cent	Maximum per cent
Pigment	65	67
Vehicle (containing at least 30 per cent fixed drying oils)	33	35

5. *Pigment.*

	Minimum per cent	Maximum per cent
Inerts† (fibrous talc, Asbestine or other siliceous material or a combination thereof)	30	32
Lithopone (light fast)	55	60
Zinc oxide (lead free)	10	12

6. *Vehicle.*—The vehicle shall consist of the best quality of fixed drying oil, Japan drier and volatile thinner so proportioned in order to obtain a paint of the required color, durability and drying time. The fixed drying oils used shall be of such color and quality as will not darken under service to impair the paint's visibility and shall furnish the maximum elasticity and durability.

*For a description of the apparatus, see Proceedings of the Fifth Annual Meeting, National Research Council, Highway Research Board, Part 1.

†The inerts as specified shall have an approximate mechanical analysis (grading) of

	Per cent
Passing 50-mesh sieve	100
Passing 100-mesh sieve	30

Traffic Striping Cost $40 Per Mile

Roads and Streets for July, 1933, contains the following:

Practically 3,500 miles of traffic stripe were placed on the state highway system of California in 1932 at an expenditure of about $163,000, according to California Highways and Public Works. This includes restriping some of the heavier traveled sections in the Los Angeles and San Francisco territories. On the average, it cost $40 per mile for placing a 4-in. stripe during the last year.

Fifteen gallons of traffic lacquer were used per mile of stripe which represented about three-quarters of the expense. On all the striping work, whether handled by day labor forces or under contract, particular care is taken to secure a true, even line. The specifications require that a deviation of more than ½-in. from the true line in a distance of 20 ft. indicates the standard maintained.

Concrete Curbing

Specifications, Massachusetts Department of Public Works

Description.—Concrete curbing shall be set to the required line and grade on a bed of gravel and in accordance with these specifications. The concrete shall be composed by volume of one (1) part of Portland cement, two (2) parts of sand and four (4) parts of broken stone or screened gravel, and such a quantity of water as directed.

The curbing shall be twenty-four (24) inches in depth, six (6) inches in width at the top, and seven (7) inches in width at the bottom.

The upper edge of the face of the curbing shall be protected with a galvanized steel curb bar.

Materials.—The cement, water, sand and broken stone or screened gravel stone shall conform to the requirements of Section 92 [not quoted here] excepting that the stones shall vary in size, from one-half (½) of an inch to one and one-quarter (1¼) inches in their largest dimensions.

The curb bar shall be made of domestic steel of good quality and galvanized and shall be of a type satisfactory to the engineer.

Construction Methods.—The trench for the curbing shall be eighteen (18) inches wide, and its subgrade shall be twenty-eight (28) inches below the top of the finished curbing.

Upon this subgrade, clean, coarse gravel shall be placed and thoroughly tamped so that it will be four (4) inches in depth after tamping.

Curbing shall be moulded in place in sections six (6) feet long and provision made at each joint for an expansion of one-sixteenth (1/16) of an inch.

The curb bar shall be placed in a satisfactory manner immediately following the placing of the concrete, in the upper edge of the face of the curbing.

The concrete shall be of such consistency and be so spaded and worked that a smooth mortar face will be produced.

All forms shall be set true to line and grade and held rigidly in position. They shall be either of metal or of acceptable planed and matched lumber, and of such construction that a smooth surface will be provided.

The forms shall be left in place as directed until the concrete has set sufficiently so that they can be removed without injury to the curbing. The curbing shall immediately upon the removal of the forms be rubbed down to a smooth and uniform surface, but no plastering will be allowed. For this work a competent and skillful finisher shall be employed.

The contractor shall protect the curbing and keep it in first-class condition until the completion of the contract. Any curbing which is damaged at any time previous to the final acceptance of the work shall be removed and replaced with satisfactory curbing at the contractor's expense.

After the forms have been removed, the trench shall be back-filled with gravel to the depth required and thoroughly tamped, care being taken not to affect the line or grade of the stone.

Basis of Payment.—This work will be paid for at the contract unit price per lineal foot of concrete curbing, complete in place, which price shall include all materials (except gravel borrow used for foundation and backfilling), all excavation (except ledge), and including all work incidental thereto.

Maintenance Costs

The tables here given are taken from *Low Cost Roads and Bridges* by Victor J. Brown and Carleton N. Connor.

The text accompanying them points out the importance of explaining and standardizing data used in comparing maintenance costs. Quality of maintenance, cost accounting, type of equipment used, traffic, width of surface, climatic conditions, variations in labor, and other items, are cited for consideration in this connection.

Table I—Surface Maintenance Costs

From Official Ohio State Highway Department Records
(Exclusive of Snow Removal)
Average Surface Maintenance Costs Per Mile Per Year

Type	1925	1926	1927	1928	1929	1930	Miles Maintained 1930	Six Yr. Aver.
Concrete	$154	$151	$168	$138	$158	$256	2,290	$176
Brick, rolled base	325	529	496	369	435	525	1,217	448
Brick, monolithic and semi-monolithic	176	230	293	300	421	281	280	311
Bituminous concrete	608	371	714	354	405	870	221	571
Rock asphalt	190	351	470	524	438	485	167	474
Sheet asphalt	210	860	433	679	191	370	49	456
Bituminous macadam	400	472	613	392	420	571	1,606	479
Waterbound macadam	470	558	954	593	546	804	1,420	658
Traffic-bound macadam	467	345	470	594	691	950	2,882	609
Traffic-bound macadam surface treated	...	...	...	...	...	1,190	1,362	1,190*
Average—All Types	$448	$390	$515	$432	$488	$715	11,572	$508

*One year average.

In Table I, note that a 6-year average surface maintenance cost on a large mileage of untreated traffic-bound macadam was $609 and that the surface maintenance cost of a surface treated traffic-bound macadam was $1,190.

Actually, the surface treatment must have made a better road than the untreated macadam and its maintenance cost should have been less. The reason for this apparent inconsistency is plain. The surface treatment probably cost about $1,000 per mile and should have been considered as resurfacing or as a betterment rather than as maintenance.

If any of the other types in this Ohio list had been resurfaced, then their "maintenance" cost also would have increased at least $1,000 per mile for the first year.

In Table II again we find apparent inconsistencies—such as the maintenance cost of a graded road being less than for asphalt or concrete, and gravel less than bituminous macadam.

The answer is that traffic is light on the graded and gravel roads and that little money is needed or expended to keep them in repair; whereas the bituminous macadam and asphalt or concrete are heavily traveled or poorly constructed or both. Maintenance on the lower type, very low traffic surfaces is knowingly slighted.

Michigan more nearly approaches the true basis for comparison as indicated in Table III of average maintenance costs per vehicle mile per year.

Patrol Street Cleaning at Toronto, Ontario

The following is from ROADS AND STREETS for July, 1932:

During the summer of 1931, the Department of Street Cleaning of Toronto, Ont., removed 136.85 cu. yd. of street sweepings, an average of 15 cu. yd. per 1,000 sq. yd. per season. A daily average of 30 4-yd. wagons, 5 2-yd. carts and 6 motor trucks were required in the pick-up service, while 215 patrolmen, at an average weekly wage of $30, were constantly in service from April until December. In his annual report George W. Dies, street commissioner, gives the following statement showing the cost of hand-broom sweeping of improved streets in 1931:

Total cost (foremen, labor, cartage, supplies)	$309,474
Area of improved street mileage (sq. yd.)	9,048,166
Cost of maintenance per 1,000 sq. yd. per season	$34.23
Amount of sweepings collected (cu. yd.)	136,858
Cost per cu. yd. (sweepings, collecting and removing)	$2.26
Cu. yd. removed per 1,000 sq. yd. per season	15
Number of patrolmen	215
Average area maintained per patrolman (sq. yd.)	42,000
Average number of times swept per season	90
Cost of sweeping per 1,000 sq. yd. (sweeping, collecting and removing)	$0.38
Cost of sweeping per mile	6.38

Each patrolman maintains an average of 3 miles of roadway, covering an area of 42,000 sq. yd. The downtown and business districts receive constant attention, while the outlying or residential districts are swept once a week.

Table II

Surface Maintenance Costs
From Utah State Highway Department Reports
Average Surface Maintenance Costs Per Mile Per Year

	Concrete	Bituminous Pavements	Asphalt on Concrete	Bituminous Macadam	Oiled	Gravel	Graded	Unimproved
1928	$ 91.53	$125.97	$261.00	$584.12	$475.00	$238.10	$114.61	$23.81
1929	114.93	136.74	73.33	248.58	179.94	224.93	112.87	43.95
2 Year Average	$103.23	$131.35	$167.16	$416.35	$327.47	$231.51	$113.74	$33.88
Miles Maintained, 1929	220.51	51.38	11.48	5.05	310.12	1,285.52		

Table III

Total Maintenance Costs* in Michigan

Table 1. Average Maintenance Costs Per Mile Per Year

Type	1924	1925	1926	1927	1928	1929	(1)	Six Yr. Ave.
Cement concrete	$555.53	$362.27	$440.04	$ 562.26	$525.99	$628.84	1,658.12	$523.42
Brick	275.19	186.26	752.08	1,117.47	691.02	667.10	5.80	600.45
Bit. conc. on gravel or conc. base	610.94	376.62	397.12	624.29	663.21	764.82	118.55	597.36
Bit. macadam	726.09	579.01	425.81	558.63	649.50	629.53	43.80	621.86
Waterbound macadam	657.83	572.99	778.66	671.72	.....	.....	...	655.51[2]
Bit. surf. treat. macadam	.....	.....	.....	.....	758.60	848.89	196.88	797.98[3]
Tar or bit. treat. gravel	.....	.....	.....	1,252.71	884.75	830.31	73.20	942.27[4]
Gravel	552.71	425.30	644.52	716.37	879.70	951.31	2,874.30	708.88
Stamp sand	423.44	291.74	333.11	359.44	890.33	912.37	79.50	616.83
All types	$503.18	$387.17	$573.26	$ 669.63	$765.06	$808.91	7,302.97	$620.17

Table 2. Average Maintenance Costs Per Vehicle Per Year

Cement concrete	$0.001080	$0.000688	$0.000754	$0.000595	$0.000624	$0.000670	1,658.12	$0.000681
Brick	0.000719	0.000385	0.001238	0.001557	0.001003	0.000784	5.80	0.000972
Bit. conc. on gravel or conc. base	0.000927	0.000654	0.000529	0.000500	0.000712	0.000814	188.55	0.000700
Bit. macadam	0.002043	0.002292	0.001540	0.001169	0.002149	0.002363	43.80	0.001896
Waterbound macadam	0.003158	0.003453	0.004689	0.002575	.....	.....	.....	0.003409[2]
Bit. surf. treat. macadam	.....	.....	.....	.....	0.002799	0.003760	196.88	0.003175[3]
Tar or bit. treat. gravel	.....	.....	.....	0.007036	0.004771	0.002566	73.20	0.003940[4]
Gravel	0.004109	0.004016	0.004612	0.005179	0.005634	0.005937	2,874.30	0.005063
Stamp sand	0.003884	0.003078	0.005345	0.001640	0.006168	0.004625	79.50	0.004661
All types	$0.002626	$0.001978	$0.002236	$0.002001	$0.002102	$0.001990	7,302.97	$0.002114

[1]Mileage maintained during 1929; [2]4 year average, all waterbound macadam was surface treated by end of 1928; [3]2 year average; [4]3 year average.

*Table includes following features of maintenance work: work on grade, bridges and culverts, dragging and patching, dust layers or surface treatments on waterbound macadam and gravel roads, resurfacing of gravel and stamp sand roads, snow removal, taking traffic census and enforcing truck loading laws in spring and fall, markers and signs, and overhead and supervision chargeable to individual maintenance sections.

Guide Posts

Specifications, Vermont State Highway Department

Description. This item shall consist of furnishing and erecting wood posts where indicated on the Plans or directed by the Engineer.

Material.

(a) *Posts.* All wood posts used shall be as specified under Item 67, Cable Guard Rail. (Not quoted here.)

(b) *Paint.* The material for and method of painting the posts after erection shall conform to the requirements as specified under Item 66, Wood Guard Rail.

(c) *Preservative Treatment.* All wood posts shall be given a Preservative treatment as specified in Item 66, Wood Guard Rail.

Construction Methods. These posts shall be erected and spaced as shown on the Plans or as directed by the Engineer. The posts shall be set vertical to full depth. The post holes shall be backfilled with suitable material and thoroughly tamped in layers of not more than six (6) inches, care being taken that the posts remain vertical. Any portion of the wood posts showing creosote over six (6) inches above the ground line shall be coated with shellac before painting. After satisfactory erection all posts shall be painted as required under Wood Guard Rail, Item 66.

Method of Measurement. The number of Wood Guide Posts under this item shall be the number of such posts erected in accordance with the Plans or orders of the Engineer.

Basis of Payment. This work shall be paid for at the contract unit price for each guide post, complete in place, and shall include all materials, equipment, tools, labor and work incidental thereto for the satisfactory completion of the work; also all excavation, refilling and disposal of surplus material.

State or Federal Aid Markers

Specifications, Vermont State Highway Department

Description. State or Federal Aid Markers shall consist of the erection of Marble markers as indicated on the Plans or as directed by the Engineer.

Material. Unless otherwise specified, the marble posts with the proper markings will be furnished by the State, f.o.b. railroad nearest the site of the work.

Construction Methods. The markers shall be erected in accordance with the standard Plans or as directed by the Engineer. The markers shall be set vertical and the excavated material shall be thoroughly compacted around the marker. The cobble stones placed around the base of the markers shall be of a uniform size, satisfactorily set in a cushion of sand and painted with two coats of approved white paint. The contractor will be held responsible for all markers delivered to him in good condition by the railroad company and he must replace, at his own expense, all such markers as may be broken by his employees or otherwise after such delivery.

Method of Measurement. The number of State or Federal Aid Markers under this item shall be the number of such markers set completely in place as shown on the Plans or as directed by the Engineer.

Basis of Payment. This work shall be paid for at the contract unit price for State or Federal Aid Markers and the price shall include hauling and erection of the markers, the furnishing and placing and painting of the cobble stones and the necessary sand cushion; also all material, equipment, tools, labor and work incidental thereto and all excavation, refilling and disposal of surplus material necessary for the satisfactory completion of the work.

Specifications and Contract Procedure for Snow Removal in Ontario

Following are excerpts from a paper by W. L. Saunders, Resident Engineer, Port Hope, Department of Highways of Ontario, presented at the 1933 Convention of the Canadian Good Roads Association, and reprinted in *Roads and Streets* for October, 1933, pages 382-386:

During the past winter the mileage of King's highways to be kept open for traffic was divided into 35 sections, 27 of which were on a contract basis, seven looked after by department of highways equipment, and the heavy section around Ottawa jointly by a contractor and a department plow. We believe the specifications for snow clearing as used by the department of highways of Ontario during the past winter were most satisfactory both from the standpoint of the department and the various contractors. In this province there are quite a number of contractors equipped with heavy trucks which are very suitable for snowplowing, and as they would otherwise in most cases be out of commission during the winter months, it is quite advantageous to employ as many as possible during the winter.

All plows used by the department of highways in Ontario are owned by the department, those used by the contractors being of the V-type. On the sections where snowfall is the heaviest the department have heavy motor trucks of their own capable of driving a rotary plow if necessary, these being kept available and readily interchanged with either a blade or V-plow as required.

The specifications for snow clearing as compiled by the department of highways of Ontario pretty well assure the procuring of suitable trucks for the purpose, and it would probably be not out of place to deal briefly with some of the clauses included therein.

Ontario Specifications for Contract Work.—Trucks are to be in good condition and must be approved by the department, this implying an inspection by a qualified motor mechanic. Contractor to supply drivers for each truck and must also be prepared to operate truck continuously day and night, Sundays and holidays, if required. Drivers shall be relieved at the end of ten hours. The department will supply a helper for each truck driver, the helper being directly responsible to the resident engineer for the proper operation of the plow, and also for the keeping of a diary and record of the plow operations. Contractor to supply gasoline, oil and repairs to his own truck. Department will maintain the snowplow. Contractor must furnish, with his tender, a bond covering all public and personal liability and in addition the department will retain a lump sum of $300.00 until all outstanding accounts are paid. Contractor to supply his own heated garage, preferably at either end of his beat. Drivers must be available by telephone. The contractor will be paid a flat rate per day of 24 hours for the supply of truck, driver, together with storage accommodation, and in addition he will be paid a tendered price per hour for the actual time worked. The payment of the contractor will only be made if his truck is in proper repair and able to operate. The contractor shall be required to work on any section other than the one on which his tender is accepted, when so ordered by the department and when so doing shall be paid his tendered rate per hour, and in addition shall be allowed actual expenses of his driver and stabling of truck when off his own section.

The department supplies suitable storage for their own plows and trucks and make every provision for their drivers being available at any time, night or day, the department being particularly fortunate in having truck drivers available who have been engaged in driving snowplows for several years past.

In concluding my remarks on the matter of snowplows, it is my own opinion that if snowplows get started as soon as the first indication of a blockade is evident and are kept in an efficient working condition that the V-type plows at present in use can cope with most of our snow conditions, it being necessary to only have rotary plows available to assist in the worst storms.

Cost Analysis of Snow Removal in Michigan

V. R. Burton, Engineer on Special Assessments, Michigan State Highway Department, gave the following in ROADS AND STREETS:

Cost Analysis of Snow Removal.—The factors considered in the accompanying table of cost analysis were first temperature, second wind direction and third topography. That cost per inch mile of snow removal varies also with the snowfall is true, but enough cases were not available to bring out this variation in detail except as shown in the table. These figures were derived from a cost computation over the entire 1924-25 winter system.

Each trunk line road across an entire county was considered a unit in most cases, and the average removable snow, temperature, wind direction and topography applied to this road. Trunk Line lengths across Michigan counties will average about twenty-five miles. There will be large variations from the average of the factors considered in even this short distance in the Upper Peninsula and therefore in some Upper Peninsula counties the distance was reduced.

The cost per mile for each trunk line road in the county was computed from the cost records of the individual maintenance sections. The cost of snow fence is assumed to be a 2 per cent depreciation charge plus the labor of erection and dismantling. There is unquestionably a great difference in the efficiency of the organizations doing this work which is reflected in cost but the more glaring examples which were known to us have been eliminated and the others compensated for in the second part of the table.

The amount of removable snow was determined by snow fall records, temperature records and the dates on which our records show plows to have been used. The reduction secured from the reduction curve showed only from 1 to 6 inches reduction during the removal period. The snow which fell before and after plows were used varied from 1 to 30 inches, in a total annual snowfall of from 25 to 60 inches.

From the amount of removal snow and the cost per mile the inch mile costs were made up. These costs were grouped into four temperature ranges, first those which occur in sections which had a mean temperature during the removal of less than 18°. This includes all but one Upper Peninsula County. The second classification was from 18° to 20°, third from 20° to 22° and four from 22° to 25°.

Topography is clasified as flat, which included the glacier lake beds and outwash plains, gently rolling the till plains; rolling the moraines and hilly the heavy moraines and rocky outcrops. This classification is admittedly vague and over as long a stretch as 25 miles subject to considerable variation. The predominating classification is used, however, and is in most cases, sufficiently accurate when dealing with so many large variables.

Culture has not been considered as important as it should be put in those counties from 20° to 25° included in the cost analysis the flat and gently rolling land is largely cultivated land. There is a larger proportion of wooded land in the rolling land. In the counties below 18° the country is generally more wooded especially the two flat stretches noted. Conditions among counties in the same temperature classification are in general quite similar.

Wind direction is given as quartering, parallel to quartering and quartering to cross. Assuming 30 degree divisions of the quadrants for this classification. This in-

Analysis of Snow Removal Costs
Winter 1924–1925.

Number of Counties studied	Mean temperature during removal period	Inches removable snow variation		Topography: Flat — Direction of Wind // to ¼	Flat — ¼	Flat — ¼ to x	Gently Rolling — // to ¼	Gently Rolling — ¼	Gently Rolling — ¼ to x	Rolling — // to ¼	Rolling — ¼	Rolling — ¼ to x	Hilly — // to ¼	Hilly — ¼	Hilly — ¼ to x
									Actual Schedule of Unit Costs						
			Average												
			Inch mile cost		1.45										3.20
8	Below 18°	30–80	% of ¼ wind		100										100
			No. cases		2										10
			Average												
			Inch mile cost	1.74	1.92	2.61	1.60	1.85	2.86	1.66	2.29	213			
11	18°–20°	7–20	% of ¼ wind	91	100	136	87	100	155	73	100	93			
			No. cases	1	4	4	3	5	5	1	4	4			
			Average												
			Inch mile cost	1.25	1.33	2.28	0.69	0.69	0.56	0.57	0.81	0.97			
17	20°–22°	7–20	% of ¼ wind	94	100	171	100	100	81	70	100	120			
			No. cases	5	5	2	5	7	1	4	4	6			
			Average												
			Inch mile cost	2.81	3.93	4.32		2.48	2.97	2.54	2.00	2.79			
8	22°–25°	5–30	% of ¼ wind	72	100	110		100	112	127	100	140			
			No. cases	2	2	3		4	1	1	4	1			
									Possible Schedule of Unit Costs						
			Average												
8	Below 18°	30–80	Inch mile cost		2.00										3.50
			% of ¼ wind		100										100
			Average												
11	18°–20°	7–20	Inch mile cost	1.70	1.90	2.65	1.70	1.90	2.65	1.70	2.10	2.50			
			% of ¼ wind	90	100	140	90	100	140	80	100	120			
			Average												
17	20°–22°	7–20	Inch mile cost	1.25	1.40	2.00	0.60	0.75	0.90	0.65	0.80	0.95			
			% of ¼ wind	90	100	140	80	100	120	80	100	120			
			Average												
8	22°–25°	5–30	Inch mile cost	2.70	3.00	4.20	2.00	2.50	3.00	1.80	2.00	2.80			
			% of ¼ wind	90	100	140	80	100	120	90	100	140			

formation was secured from weather bureau reports of prevailing wind direction during the snow removal period.

Two tables are shown in the cost analysis, first the actual schedule of average unit costs and second a table of possible unit costs weighted both according to the number of cases to be had and from personal knowledge of the class of work done in each case. This weighting was done to give a more consistent arrangement of percentage variations. It will be seen on comparison with the actual costs that this re-arrangement has been done without too serious mishandling of the actual costs.

Discussion of the Cost Analysis.—In discussing this cost analysis it should first be stated that except for the range of snowfall shown as below 18° there seems to be little or no relation between the amount of snowfall and inch mile costs over the range covered. That is, in a number of cases it cost just as much per inch to move 30 inches as it did to move 5. Above the 30 inches and with temperatures below 18° however, there is an apparent increase in cost as the amount increases. Due to the fact that in some cases the class of service was not comparable, for the present at least, only the averages will be used.

We should naturally expect that the inch mile cost should increase with the snowfall and if the costs of the next higher temperature classification are compared this is found to be the case. This is due to two reasons, first there begins to be at about a 30 inch amount of removable snow, as much more general use of tractor plows and these are more expensive units to operate than the trucks used for smaller amounts. Second, as the winter goes on, the accumulations of snow at the side is a more serious means of increasing the cost in the higher snowfalls, from the additional drifting caused by it and the increased difficulty of getting the snow back.

It might be assumed that the total cost of removal would vary more consistently with the number of trips made rather than with the total amount of snow moved during the season. This did not prove to be the case even though in some instances the number of trips exceeded the number of storms by 100 per cent. If the number of hours spent on the trip were taken into account they would of course be a direct index of the cost, but due to variations in the time of trips, the number of trips gives little information as to relative costs. The time consumed is in general proportional to the amount of snow moved when this time and snow moved is averaged over the whole season.

While there was some overlapping of unit costs by sections near the limits of the temperature division chosen, yet the general run of individual costs was quite consistent, really surprisingly so in the case of the 20° to 22° division. There are of course always bound to be inconsistencies due to the class of service rendered, efficiency of the organization operating, amount of traffic on the road, use or non-use of snow fence, etc., even if all our other factors were mathematically exact, which they are far from being.

The most remarkable variation in cost per inch mile is shown by the classification according to temperature. It should be remembered that this cost variation is due to the product of two factors, first the depth of drifting and second the cost of removing the particular class of snow encountered through that depth. It can easily be seen then that there may be a temperature at which a minimum cost may occur due to the minimum product and not the minimum of either factor.

Throughout all ranges of topography and wind conditions the cost per inch mile from seventeen different counties with a mean daily temperature of 20° to 22° is consistently less than for temperatures either above or below this temperature range. Drifting is not so serious at this temperature as it is at the lower temperatures and the cost of moving an inch of drifted snow is not so high as it is in the temperatures above. We have here then the condition of snow removal at the minimum cost per inch mile.

As the temperature drops below 20° the amount of drifting increases faster than the decreased cost of moving a lighter snow and we get increased costs. The inconsistency noted in the actual schedule of the table for the flat topography below 18° is explained by a difference in culture. The two instances studied are from Upper Peninusla counties where the land is much more wooded and hence protected from drifting.

As the temperature goes above 22° the snow gets heavier and more difficult to move since thaws are much more frequent. The cost of moving this kind of snow increases faster than the decreased amount of drifting. This may seem like a rather far fetched explanation to account for these cost variations and if the roads could be kept continually clear without any interruption of service it is doubtful if so marked a difference in cost would be shown. To permit a road to fill up and then remove the parked snow after it has frozen and thawed for a day or two is a certain means of increasing costs. Increased speed of removal in these regions of higher temperature will unquestionably lower the averages given.

In one county, Monroe, with a temperature average of 25.7° and a 10 to 12 inch amount of removable snow there was some indication that the decreased amount of drifting had lowered the unit cost in spite of the increased weight of the snow but not enough data was at hand to draw any definite conclusion.

Effect of Topography on Cost of Snow Removal.—Let us now examine the effect of the difference in topography on the inch mile cost of snow removal. It will be noticed that the 22° to 25° temperature range with a 5 to 30 inch variation in removable snow the cost decreases fairly uniformly from flat to rolling country. In our adjusted table this varies, using the quartering wind as a standard from $2 to $3 per inch.

In the flat country included in these counties from which the data on temperature range from 18° to 25° was derived, as has been stated, a majority is cultivated land. On a terrain of this character the wind gets a long clear sweep across the fields picking up the snow as it travels along the surface and deposits it at the first obstruction to its progress. This obstruction need not be any more serious than a woven wire fence especially if weeds and brush are allowed to stand along the fence row. Tighter obstacles such as picket or board fences of course increase the amount of drifting. The various rights of way of from 50 to 66 feet do not give sufficient clearance between road and fence, and the drift forms in the roadway.

Drifts in this sort of country are characterized by only medium but very uniform depths extending for long distances along the road. There are no appreciable side slopes to absorb any of the snow accumulation or break up the sweep of the wind and the top slopes of the drift is therefore very flat throughout most of its length. These long comparatively shallow drifts are removed and the ridge accumulation along the side aggravates further drifting until before the winter is over surprisingly large amounts are on the ground.

The factors which tend to reduce the cost through this temperature and snowfall range over the more rolling country are several. First, as has been stated, especially

in that part classified as rolling, more wooded land is seen. Second, where the snowfall range is no higher than it is and with temperatures this high the storage capacity of the side slopes of the larger cuts is not so often exceeded and less snow drifts in the roadway. Finally, long stretches of roadway on fills will be swept bare of any snow at all. As we pass from flat through gently rolling country to rolling there are of course, all sorts of variations of these factors.

On examining the next lower temperature class from 20° to 22° the importance of the flat topography is still evident, although the cost is reduced. The gently rolling country shows the minimum cost, although between rolling and gently rolling not much difference is seen. The importance of the larger drifts in rolling country begins to be evident, however, with the increased drifting caused by the drop in temperature. The increased amount, however, does not yet overbalance the decreased cost of the lighter snow.

When the temperature drops to from 18° to 20° the increased drifting materially raises the unit costs. The larger drifts cause much more trouble, and it is now more a question of depths of snow than it is the quality. As we would expect, little difference is seen between flat and gently rolling country. The heavier cuts in the rolling country are now of somewhat more importance in their reflection of inch mile cost.

When we get into the Upper Peninsula the cuts in the rolling and hilly country are of much more relative importance and cause a serious increase in cost. These extremely bad cuts and the heavy drifts which form in them not only influence the cost from their depth alone, but due to the rapidity with which they fill, will not permit of the continuous method of removal so essential to low costs.

Summing up the discussion of the effect of topography on snow removal cost, then, we see that from a certain temperature of minimum inch mile cost the cost increases with the roughness of the topography as the temperature falls and decreases with the roughness as it rises.

Prevailing Wind Direction as Factor in Drifting.—As was shown in a preliminary study of Michigan snow problem, the matter of wind velocity for a range in value no greater than those shown in our state is unimportant when studying a full season's work. The prevailing wind direction, however, has been found to be a more considerable factor than was at first supposed when applied to locations of similar snowfall and temperature. There are more inconsistencies, naturally, in a study of so variable a quantity because a few storms which do not come from the direction of the prevailing wind may cause trouble on a section comparatively drift free when normal winds are blowing. In general, though, where the larger number of cases are compared cost variations are fairly consistent, at least so far as sign is concerned.

The reason that the amount of snow drifting into the road varies with the direction of the winds is perfectly obvious, yet it may be well to state it. There is no less snow moving along the surface in a parallel wind than in a cross wind, but the axis of the drift is parallel to the direction of the wind. The inclination of the wind's direction to the center line of the road, then, largely determines whether or not a drift of given length will reach to the roadway. By length we mean, of course, its direction parallel to the wind.

The quartering wind is adopted as a standard of comparison, as it is much more frequently met in our state, where the prevailing winter winds are largely N.W. and S.W., quartering our section line roads. About all that we can safely say at present about these variations is that with the quartering wind as a standard it costs from 10 to 20 per cent less on those roads whose prevailing wind direction is from parallel to quartering, and 20 to 40 per cent more on those roads where this direction is from a quartering to cross wind.

This completes our cost analysis, and I wish to again emphasize the fact that these figures shown as possible costs are tentative. They are the only ones we have which are at all reliable, but are certain to be modified as our range of snowfall studied is increased and a sufficient number of years' records is available to bring the costs to a closer approximation to the mean. It is felt, however, that the method of comparison outlined may prove of value to those whose situation is somewhat similar to our own. It is a logical method and so far as is known is the first of its kind attempted.

Snow Removal Methods and Costs in Various States

General Methods.—Throughout past winters various types of equipment have been employed for removing snow from the highways. At first, ordinary road maintenance equipment was pressed into this service but as experience was gained, different equipment was devised until in late years the truck and tractor plow is displacing the greater outfits.

Mr. H. G. McKelvey, of the division of construction of the U. S. Bureau of Public Roads, compiled data collected from the 36 state highway departments within the snow area. Information contained herein is taken from his compilation. He states that the total cost of the service on the 111,645 miles of main highways as reported was slightly in excess of five million dollars, averaging approximately $45 a mile.

As there is little doubt that the work of removal has been conducted with increasing efficiency each year, the increase in cost per mile probably reflects a tendency—once the benefits of clearing have been demonstrated—more and more completely to remove the snow that falls. Undoubtedly the work done at an average cost of $45.18 a mile in 1927-28 represented a much more complete service than that which in 1922-23 was done at a cost of $28.12 a mile. In this connection it may be observed that the reports for the season 1927-1928 indicate that the snowfall in 22 of the 36 states was unusually light. Had the precipitation in these states been heavier the average cost per mile for the year would doubtless have been higher.

Trend Toward State Control.—In 17 of the 36 states in which snow was cleared from the highways in 1927-28, all work done was under the supervision of the state highway department. In 15 other states work was done by both the state and the counties or other local governments. In some of these states the state highway department cooperated with the local authorities, in others the counties independently cleared certain roads under their jurisdiction and so added to the mileage cleared by the state. In only 4 states in 1927-28 was the work done solely under local control.

In 1922-23, the first year for which reports were received, the work was done exclusively by the state in 11 states, by both the state and the local governments in one state, and exclusively by the local governments in 8 states. Since that year there has been a steady trend toward increased activity by the state and decreased activity by the local governments.

Snow-Removal Costs.—To determine approximately the cost of snow removal, the Bureau of Public Roads

made a brief study during the year 1927-1928 of the expenditures in those states and counties where records were most readily available. The territories selected are fairly representative, and their costs in each case have been reduced to a cost per inch-mile of snow removed.

These figures are not expected to supply a reliable scale with which to estimate the cost of snow removal from rural highways generally, but it is believed that they will suggest within reasonable limits, the probable cost of work of this nature in areas of similar snowfall and temperature and like working conditions.

While the average total depth of snowfall over the entire area during the season is employed in calculating the cost per inch-mile for its removal, it is well known that it is never necessary to remove all the snow that falls. When the temperature is above the freezing point during or after the storm the snow melts rapidly and does not need to be removed. Also it is the practice in most states not to remove snow which falls to depths of less than 2 inches. For these and similar reasons the costs per inch-mile reported hereafter are probably lower than the true costs of the work actually performed.

However, it will be observed that the costs reported in many instances include capital investments which rightly should be charged to the work of several years, but which, because of the inadequacy of accounting methods employed, it is not possible so to distribute with sufficient accuracy to warrant the attempt. The inclusion of these items would tend to increase the cost.

For these and other reasons the costs which are presented hereafter should be regarded as rough approximations. So regarded, it is believed that they will be found useful until such time as more accurate analyses may be possible.

Table 3 shows the snowfall, temperature, cost of snow removal per inch-mile of road, equipment used and other data for the entire state of Iowa, segregated by districts. District No. 5 is located in the southeastern part of the state, where the weather and other conditions prevailing during the winter of 1927-1928 contributed towards reducing the cost of the removal work to a minimum. Because of the unusually low total cost of the work, the data were not considered representative and the average per inch-mile was not computed.

The mileage under the caption "Road Cleared" includes the roads in each district where snow removal may be required, but certain sections may be so located topographically as to make little if any clearing work necessary during the season, while other sections may need strenuous efforts in order to keep them open and passable.

The state reports that 90 per cent of the roads in the various district programs were protected from drifting conditions with snow fence or by other means, where such protection was considered necessary. For Districts 1, 2, 3, 4, 7 and 8, it has been estimated that 80 per cent of the work was on initial or patrol clearing, and 20 per cent on widening operations. For District 5, all of the work represents initial clearing, and for Districts 6 and 9, 90 per cent was initial and 10 per cent widening work. The total cost items include purchase of equipment; purchase, installation and removal of snow fence; wages paid laborers, foremen, and motor drivers, and the salary of the maintenance superintendent.

Methods and Costs of Snow Removals in New York. —The state of New York experiences generally considerable snowfall. Its removal from the main highways is accomplished by the counties or townships, and in some instances by both. In Table 4 are given data on the cost per inch-mile for several counties in the western, central and eastern sections of the state.

Chautauqua County lies along the shore of Lake Erie, and in the extreme southwestern part of the state. Approximately 60 per cent of the work involved consisted of initial or patrol clearing, and 40 per cent of widening operations. About 30 per cent of the total expenditure was for the purchase of equipment; 18 per cent was for the purchase, installation and removal of snow fence; 17 per cent was for wages of labor, foremen, motor drivers and for superintendence; 10 per cent covered depreciation, upkeep or rental of equipment, insurance on labor, etc., and 25 per cent was for such items as gasoline, oil, garage charges and materials. The superintendent of highways in charge of this county contends that the cost of snow-removal work does not depend so much on the depth of fall as upon the direction and intensity of the wind during the precipitation. Attention is called to the fact that the cost per inch-mile for this country was computed from a total cost, about 30 per cent of which was used for the purchase of equipment, and 18 per cent for the purchase and manipulation of snow fence.

The main highways of Cattaraugus County, adjoining Chautauqua County on the east and forming a part of the southern tier of the state, were covered with a total of approximately 55 inches of snow during the winter of 1927-1928. The aggregate cost indicated for the removal work includes the amount spent for labor, foremen, motor drivers and superintendents, and estimated amounts to cover overhead expense, upkeep of equipment, insurance on labor and miscellaneous items. Seventy per cent of the work was initial or patrol clearing, and 30 per cent was the widening of preliminary cuts. In addition to the total shown, the county expended $7,900 for the purchase of new equipment and snow fence. The installation and removal of snow fence was accomplished by the townships. It is reported that 50

Table 1.—Snow-Removal Mileage and Expenditures in the 36 Heavy-Snowfall States During the Five-Year Period From 1923 to 1928

Winter	Total mileage of roads cleared of snow, miles	Increase over preceding year per cent	Total cost of snow removal	Increase over preceding year per cent	Average cost per mile	Increase over preceding year per cent
1922-23	27,096	....	$ 762,159	....	$28.12	....
1923-24	41,302	52	946,262	24	22.91	—18.5
1924-25	62,167	50	1,826,813	93	29.39	28.3
1925-26	93,006	50	3,757,663	106	40.38	37.4
1926-27	106,721	15	4,641,037	24	43.50	7.7
1927-28	111,645	4.6	5,043,779	8.7	45.18	3.9

Table 2.—Equipment Used in Snow-Removal Operations in the 36 Heavy-Snowfall States During the Six-Year Period From 1922 to 1928 Beginning with the Winter of 1922-23.

Winter	Number of Truck Plows	Increase Over Preceding year, per cent	Number of Tractor Plows	Increase Over Preceding Year per cent	Total No. of Truck and Tractor Plows	Increase Over Preceding Year, per cent	Miscellaneous Equipment — Trucks	Tractors	Graders
1922-23	184	....	281	....	405	....	....	....	....
1923-24	1,227	567	287	30	1,514	274	....	....	....
1924-25	1,456	19	446	55	1,902	26	....	....	....
1925-26	2,546	75	803	80	3,349	76	3,943	1,348	1,511
1926-27	2,827	11	1,069	33	3,896	16	4,365	1,600	4,272
1927-28	3,412	21	1,275	19	4,687	20	5,239	2,245	2,075

per cent of the mileage in the program was protected by snow fence.

The total cost of the work in Erie County, surrounding the city of Buffalo, may be separated into the following items: 43.9 per cent for the purchase of equipment and snow fence; 34 per cent for the installation and removal of snow fence, wages of labor, foremen and motor drivers and salary of superintendents 22.1 per cent for the insurance of labor and for miscellaneous expenses. It is believed that the high cost per inch-mile is accounted for largely by the fact that approximately 66 per cent of the total cost was expended on purchase of equipment, insurance of labor, etc. Another factor that should be considered is that this county includes hilly terrain which is responsible for considerable drifting.

Niagara, the extreme northwestern county of the state, bounded on the west by the Niagara River and on the north by Lake Ontario, experienced an average depth of 37.5 inches of snow during the winter of 1927-28, and a mean temperature of 35.5 degrees. The data in Table 5 show that $5,537 was expended on snow removal work for the entire season. Forty-seven per cent of that sum was used for the installation and removal of snow fence and the remainder for the wages of labor, foremen and motor drivers; the salary of superintendents, estimated amounts for overhead, equipment depreciation, upkeep or rental; insurance of labor, and other miscellaneous items. Widening work was accomplished, but these costs were not segregated from the other work. All roads were protected from drifting where such protection was necessary.

Onondaga County, which includes the city of Syracuse, is well organized for the removal of snow from its rural roads. With regard to the data shown in Table 4, 75 per cent of the roads on the program were protected from drifting; 30 per cent of the work represented initial or patrol clearing and 70 per cent widening activities. The total funds expended cover the following items: $5,326 for the rental and repair of equipment, and also for depreciation, carrying charges and interest on the investment; $1,824 for the manipulation of the 8 miles of snow fence handled by the county; $7,367 as wages of labor, foremen and motor drivers, and $3,665 for supplies and other expenses.

Warren County is situated within rather a mountainous territory lying on the shore of Lake George and east and south of the Adirondack State Park. The total cost shown in Table 4 for the snow-removal work includes percentages paid for the installation and removal of snow fence; wages of labor, foremen and motor drivers and salaries of superintendents, but excludes expenditures made for the purchase of equipment or its upkeep, the initial cost of snow fence and amounts estimated for overhead expense or miscellaneous items. Six miles of snow fence were provided where drifting conditions were serious, and an ample width of cleared roadway was maintained throughout the winter.

Snow-Removal Methods and Costs in Connecticut.—The total cost of the work for the different districts includes wages paid labor, foremen and motor drivers; equipment depreciation, upkeep and rental, and other miscellaneous items, but omits costs involving the purchase of equipment, the purchase or handling of snow fence, charges for superintendence or any estimated amounts for overhead expense or insurance of labor. Both initial and widening work were carried on, but no segregation of cost of these activities was made.

The cost per inch-mile for District No. 7 is high because this district lies in the Berkshire Hills region at the northwestern corner of the state, where heavy drifts are encountered. Furthermore, although it is estimated from the United States Weather Bureau data that an average of 27.6 inches of snow fell over the entire district during the season, the state records show that 63 inches of snow fell in certain sections of the district.

Snow-Removal Methods and Costs in West Virginia.—West Virginia reported snow-removal operations for the northern part of the state only in the winter of 1927-1928. Within this section one of the engineering divisions, situated in mountainous territory, kept 271 miles of its roads clear of snow at an average cost of 45 cents per inch-mile. The mean temperature for the winter was 41.5 degrees, and open roads were maintained at a width of 16 feet. The work was done with 23 truck displacement plows, one rotary plow with a truck mount and two one-man graders. The average seasonal snowfall over the entire division was 53.2 inches, and $6,440 was the total expenditure for its removal. Twenty-eight per cent of this amount was charged against equipment depreciation; 44 per cent was for the hire of labor, foremen and motor drivers; 4 per cent for salary of superintendents; 6 per cent estimated for overhead expense; 17 per cent for equipment upkeep, gas, oil, tire repair and garage rent, and 1 per cent for handling snow fence.

Snow-Removal Methods and Costs in Arizona.—Arizona submitted snow-removal data for only one engi-

Table 3.—Snow Removal Data—Season of 1927-1928—for the State of Iowa.

Div. No.	Average Snowfall 1927-28 Inches	Mean Temperature Degrees	Road Cleared, Miles	Width Cleared Feet	Total Cost	Cost per Inch-Mile	Truck Displacement Plows	Truck Rotary Plows	Tractor Displacement Plows	Tractor Rotary Plows	Trucks	Tractors	Graders	Snow Fence, Miles
1.....	19.9	36.0	865	28	$ 38,510	$2.24	25	..	2	..	46	25	36	60
2.....	32.9	32.1	750	28	50,474	2.05	24	2	2	3	47	15	22	130
3.....	20.9	33.5	812	28	32,083	1.89	12	1	4	1	14	22	16	84
4.....	12.0	37.7	697	28	12,412	1.48	12	1	4	1	14	22	16	29
5.....	16.6	39.1	796	28	1,903	....	9	..	5	..	14	44	18	..
6.....	12.8	36.9	812	28	23,649	2.28	21	..	3	..	23	21	18	36
7.....	24.6	33.5	822	28	39,315	1.94	15	1	6	..	30	20	23	89
8.....	32.4	33.2	754	28	64,416	2.64	15	1	8	..	23	26	24	135
9.....	8.5	38.5	773	28	23,152	3.52	10	..	1	..	20	37	40	35
Total			7,081		$285,914		143	6	35	5	231	232	213	598

Note: The figures for average snowfall, mean temperature, and cost per inch-mile are approximate.

Table 4.—Snow-Removal Data—Season of 1927-1928—for the State of New York.

Counties	Average Snowfall 1927-28	Mean Temperature, Degrees	Road Cleared, Miles	Width Cleared, Feet	Total Cost	Cost per Inch-Mile	Truck Displacement Plows	Truck Rotary Plows	Tractor Displacement Plows	Tractor Rotary Plows	Trucks	Tractors	Snow Fence, Miles
Chautauqua	53.2	37.5	161	24	$ 40,500	$4.73	8	1	4	..	9	4	65
Cattaraugus	55.5	38.0	310	18	26,205	1.52	13	..	4	..	17	4	25
Erie	80.7	35.7	400	10	112,542	3.49	60	..	18	1	60	19	32
Niagara	37.5	35.5	125	16	5,537	1.18	6	..	6	..	6	6	8
Onondaga	87.1	36.3	305	22-30	18,182	.68	28	..	..	2	23	2	11
Warren	85.5	35.2	125	30	15,000	1.40	2	..	7	..	..	..	6
Totals			1,426		$217,966		112	1	39	3	115	35	147

Note: The figures for average snowfall, mean temperature, and cost per inch-mile are approximate.

neering division. This division lies in the center of the state between Maricopa County on the south and Grand Canyon National Park on the north. During the winter of 1927-28, the snowfall averaged 24.8 inches and the mean temperature was 46.7 degrees. The sections of road cleared were not continuous but were scattered over the division in areas with variable depths of snowfall. The aggregate length of road cleared equaled 146 miles with an average width of 18 feet. The equipment used consisted of 3 displacement plows mounted on tractors, and 7 graders pulled by motor trucks. Eighty-five per cent of the activities were confined to initial clearing or patrol work and 15 per cent to widening operations. The work cost $2,715, or an average of 75 cents per inch-mile. The sum total was segregated as follows: 33 per cent for hire of labor, foremen and motor drivers; 47 per cent for equipment depreciation, upkeep or rental, and 20 per cent for gas, oil and grease. Snow fences and other drift-preventive measures were not employed.

Snow-Removal Methods and Costs in Wisconsin.—As may be seen in Table 6, the roads of all divisions, with the possible exception of those in Division 9, where light snowfall was reported during the winter of 1927-1928 were protected from drifts with generous sections of snow fence. Likewise, with the exception of Division 5 and the other divisions shown blank under the caption "Width Cleared," more or less widening work was accomplished. For Division 3, 25 per cent of the total cost was for widening activities; Division 4, 35 per cent; Division 7, 60 per cent; and in Division 8, 26 per cent of the cost covered this class of work.

Divisions 3, 4 and 8 report that their total cost for snow-removal work includes purchase of equipment in the proportions of 25, 30 and 15 per cent, respectively. Division 7 reports that their total cost did not include the purchase of equipment and the remaining divisions made no report concerning this item. Division 3 supplied the information that the cost of superintendence is paid from general county funds, and Division 7 states that amounts paid superintendents and estimated charges for overhead are not included in the total cost of snow-removal work; but the other division reports generally indicated that their respective totals included the salary of superintendents. For all the divisions reporting, including 3 and 7, the total cost included, as a rule, amounts for the purchase and handling of snow fence; wages paid labor, foremen and motor drivers; estimated percentage for overhead expense; equipment depreciation, upkeep or rental; insurance of labor, and other miscellaneous items.

Cotton Fabric Reinforcement of Road Surfacing

The success achieved with test strips under service conditions of reinforcement of road surfacing with cotton fabric over a period of years in Southern States, notably South Carolina and Texas, led to the recent construction of a considerable section in one of Louisiana's main highways.

In this stretch of road extending for 2½ miles near Baton Rouge, cotton fabric constitutes a membrane between the layers of asphaltic surfacing. The application of fabric in this instance illustrates in a general way the employment of cotton in road construction. After preliminary preparation of the basic earth surface and the application of an asphaltic coating, fabric was laid while the coating still was sticky. An open weave fabric was used, weighing approximately 4½ ounces per square yard. Another asphaltic coating was applied over the fabric and the surface screenings spread to complete the job.

In this type of road construction the cotton fabric is stated to form in effect a waterproof blanket over the entire roadbed, acting as a binder, and giving additional resilience and strength to the top surface. Service tests are stated to have demonstrated that the fabric thus impregnated with asphaltic substance prevents the penetration of water beneath the surface of the road. Ravelling at the edges is also prevented. Furthermore, it is claimed, in case of a surface fracture caused by heavy impact, the fabric tends to hold the surfacing material together until the break is automatically "healed" by the rolling effect of traffic.—*From Roads and Streets for June,* 1933.

Table 5.—Snow-Removal Data—Season of 1927-1928—for the State of Connecticut.

Dist. No.	Average Snowfall 1927-28 Inches	Mean Temperature Degrees	Road Cleared, Miles	Width Cleared Feet	Total Cost	Cost per Inch-Mile	Equipment: Truck Displacement Plows	Truck Rotary Plows	Tractor Displacement Plows	Tractor Rotary Plows	Trucks	Tractors	Graders	Snow Fence Miles
1.....	14.2	39.2	181	26-50	$ 3,062	$1.19	25	..	..	..	17	..	..	..
2.....	14.9	40.4	192	26-32	4,429	1.55	25	..	..	..	18	..	..	1.5
3.....	15.0	40.6	163	26-32	6,972	2.85	25	..	..	..	16	..	..	0.8
4.....	18.7	40.7	149	26-32	3,088	1.11	25	..	..	..	13	1	..	0.1
5.....	17.9	40.2	185	26-32	6,336	1.91	25	..	..	..	14	..	..	..
6.....	17.0	39.8	239	26-32	5,703	1.40	25	..	..	..	21	..	..	..
7.....	27.6	37.7	210	26-32	19,019	3.28	25	..	..	..	32	4	..	8.5
8.....	20.5	39.8	127	26-32	5,455	2.10	25	..	..	..	19	1	..	..
9.....	23.5	39.3	177	26-32	4,386	1.05	25	..	..	..	17	..	..	0.8
10.....	26.0	39.0	150	26-32	4,335	1.11	25	..	..	..	15	..	..	0.6
11.....	29.6	37.0	178	26-32	8,980	1.70	25	..	..	..	20	1	..	0.2
Totals			1,951		$71,765		275				202	7		12.5

Note: The figures for average snowfall, mean temperature, and cost per inch-mile are approximate.

Table No. 6.—Snow-Removal Data—Season of 1927-1928—for the State of Wisconsin.

Div. No.	Average Snowfall 1927-28 Inches	Mean Temperature Degrees	Road Cleared, Miles	Width Cleared Feet	Total Cost	Cost per Inch-Mile	Equipment: Truck Displacement Plows	Truck Rotary Plows	Tractor Displacement Plows	Tractor Rotary Plows	Trucks	Tractors	Graders	Snow Fence Miles
1.....	22.9	37.8	2,565	18	$ 19,800	$0.34	21	..	19	1	30	26	42	30
2.....	32.2	38.3	3,000	..	69,276	.72	54	..	21	..	54	21	..	90
3.....	57.5	33.6	*2,100	16	80,000	.66	32	..	15	1	30	13	..	69
4.....	47.4	33.7	2,400	22	77,761	.69	24	..	9	..	24	11	5	48
5.....	51.9	33.6	1,500	10	45,000	.58	7	..	2	..	12	12	9	63
6.....	62.2	30.2	2,146	..	52,485	.39	16	..	15	..	16	15	..	54
7.....	81.1	29.2	*1,533	22	80,000	.64	12	..	15	2	16	21	..	129
8.....	73.3	28.9	1,826	20	63,676	.47	14	..	14	..	14	16	3	65
9.....	27.4	37.8	425	..	5,000	.43	1	..	2	..	14	..	..	6
Totals			17,495		$492,998		181		112	4	196	135	59	554

*Includes county roads other than trunk highways.

Note: The figures for average snowfall, mean temperature, and cost per inch-mile are approximate.

United States Government Materials Specfications

Specifications for materials used by the United States Government are prepared by the Federal Specification Board, and issued as the "Federal Standard Stock Catalog," any item of which may be purchased from the Superintendent of Documents, Washington, D. C. Note that postage stamps or uncertified checks are not accepted in payment for these documents.

Federal specifications directly applicable to road building and maintenance are listed herewith. Others, of which there are many hundred, cover a very wide range of materials, including groceries, meats, textile products, furniture, hardware, tools, instruments, brooms, insulating materials, building materials, chemicals, metal products, sewer pipe, soap, waterproofing materials, paints, hose, and automobile tires. The list is being constantly added to and revised. A complete index is published twice a year, and is obtainable from the Superintendent of Documents for 10 cents.

Insofar as applicable, these specifications are binding on all departments, bureaus, agencies, and offices of the Government.

Sources of Materials Supply.—"1. As a solution to some of the problems arising in connection with the use of specifications, there have been compiled by the National Bureau of Standards for distribution to all Federal purchasing agencies lists of sources of supply of commodities covered by certain Federal Specifications and Commercial Standards. These lists contain the names of firms who have indicated their willingness to certify to purchasers, *upon request,* that material supplied by them on contracts based upon the designated specifications and standards, *does actually comply with the requirements and tests thereof, and is so guaranteed by them.*

"2. Up to the present there have been prepared such lists of sources of supply for nearly 400 Federal Specifications and Commercial Standards. The compilation of additional lists is constantly going forward.

"3. Copies of 'willing to certify' lists have been distributed by the Bureau of Standards to all governmental purchasing agencies, and are available to other organizations upon request."

In ordering specifications from the Superintendent of Documents, the specification symbol should be stated. There is no charge for the mailing of specifications to any point in the United States.

Federal Specifications for Road Materials, Etc.

Specification symbol	Title	Price
SS-A-281	Aggregate; (for) Portland cement concrete	5c
SS-A-676	Asphalt; emulsion, quick-breaking-type (for) road work	5c
SS-A-681	Asphalt emulsion, slow-breaking-type (for use in road work)	5c
SS-A-696	Asphalt; petroleum, type PAF-1-25, (for) joint-filler (squeegee or pouring method)	5c
SS-A-706	Asphalt; (for use in) road and pavement construction	5c
QQ-B-71	Bars; reinforcement, concrete	5c
FF-B-571	Bolts; Nuts, Studs; and Tap-Rivets (and material for same)	10c
SS-B-671	Brick; paving	5c
CCC-B-811	Burlap; jute	5c
SS-C-191	Cement; Portland	10c
SS-C-571	Coarse-Aggregate; (for) Portland cement-concrete-pavement or base (crushed stone, gravel, or slag)	5c
SS-C-726	Crushed-Stone and Crushed-Slag; (for) binder-course, sheet-asphalt-pavement	5c
SS-C-731	Crushed-Stone and Crushed-Slag; (for) bituminous-concrete-base or surface-course	5c
SS-C-736	Crushed-Stone and Crushed-Slag; (for) bituminous-macadam-base or surface-course	5c
SS-C-741	Crushed-Stone and Crushed-Slag (or) Gravel; (for) bituminous surface-treatment	5c
SS-C-746	Crushed-Stone and Crushed-Slag (for) water-bound-base or wearing-course	5c
RR-F-221	Fencing; wire (barbed, netting, and woven), black and galvanized	5c
SS-F-351	Fine-Aggregate; (for) Portland cement-concrete-pavement or base (sand, etc.)	5c
VV-G-101	Gasoline; Motor, U. S. Government	5c
SS-G-651	Granite-Blocks; recut granite, and durax granite pavements	5c
QQ-I-651	Iron, gray; castings	5c
MM-L-751	Lumber and Timber, softwood	5c
SS-M-51	Materials; (for) cushion course, brick, stone-block, or wood-block pavements (sand, slag, limestone, screenings, etc.)	5c
SS-M-351	Mineral-Fillers; (for) sheet asphalt or asphaltic concrete pavements (Portland cement, limestone dust and dolomite dust)	5c
VV-M-571	Motor-Fuel V	5c
FF-N-101	Nails; spikes; staples; and tacks	10c
VV-O-496	Oil, lubricating, Class D (for internal combustion engines other than Aircraft and Diesel)	5c
VV-O-751	Oil; road, type OH-1-25, hot application	5c
WW-P-371	Pipe; concrete, plain	5c
WW-P-421	Pipe; water, cast iron (bell and spigot)	5c
RR-R-571	Rope; wire	5c
SS-S-51	Sand; (for) cement-mortar-bed, brick, stone-block or wood-black pavements	5c
SS-S-61	Sand; (for) grout-filler, brick and stone-block pavements	5c
SS-S-71	Sand; (for use in) sheet asphalt or bituminous concrete pavements	5c
RR-S-366	Sieves; standard, testing	5c
QQ-S-711	Steel; structural (for) bridges	5c
R-T-101	Tar; cold-application (for) roads	5c
R-T-111	Tar; (for) joint filler	5c
R-T-121	Tar; refined, construction (for) roads	5c
R-T-126	Tar; refined (for) crack filler	5c
R-T-131	Tar; refined, hot-application (for) roads	5c
R-T-151	Tar; repair-work (for) roads	5c
TT-W-556	Wood-Preservative; coal-tar creosote (for) ties and structural timbers	5c
TT-W-561	Wood-Preservative; creosote (for) brush and spray-treatment	5c
TT-W-566	Wood-Preservative; creosote-coal-tar-solution, (for) ties and structural-timbers	5c
TT-W-571	Wood-Preservative; preservative-treatment	5c
TT-W-576	Wood-Preservative; zinc-chloride (for) ties and structural-timbers	5c

National Directory of Commodity Specifications

The Bureau of Standards, U. S. Department of Commerce, publishes the National Directory of Commodity Specifications—a classified list, with brief descriptions, of the standards and specifications formulated by the national technical societies, the trade associations having national recognition, or other organizations which speak for industry or with the authority of the Federal Government as a whole. To supplement the classified arrangement, the directory contains a very complete subject index.

The latest edition—that of 1932—contains 548 pages, and lists nearly 10,000 specifications. It is obtainable from the Superintendent of Documents, Washington, D. C. Price $1.75.

Specifications of the American Society for Testing Materials

Following is a list of American Society for Testing Materials specifications applicable to highway materials and construction. These specifications are given in the volume of the Society's Standards and Tentative Standards for the years 1933 and 1932 respectively. A large number of specifications which have only an indirect application to highway construction, such as paints, are omitted from the list here printed.

A.S.T.M. specifications are regularly designated by the serial numbers here given following the titles. The concluding number of each designation indicates the year in which the specification was adopted as a standard or a tentative standard.

The Book of A.S.T.M. Standards is issued triennially. Those standards which are adopted by the Society in the intervening years are published annually in supplements to the Book of Standards. A supplementary pamphlet containing standards adopted in 1934, and a second supplementary pamphlet of standards adopted in 1935, will accordingly be issued during the year preceding the next edition of the Book of Standards, which will be in 1936.

The term "tentative" applies to a proposed standard published for one or more years, with a view to eliciting criticism, before it is formally adopted by the Society. The book of A.S.T.M. Tentative Standards is issued each year about October 15, and contains all tentative standards in effect in that year. Tentative standards submitted or revised in any given year appear also in the Proceedings of the Society for that year. All tentative standards are indicated by the letter "T" at the end of the reference number.

Tentative specifications and methods of test, although still in the trial stage of the A.S.T.M. procedure, represent the latest thought of the committees on the subjects covered, and therefore are finding important applications in the various industries. Since the tentative standards may frequently be used in conjunction with A.S.T.M. standards, the volume is complementary to the volumes containing the standards.

The Book of A.S.T.M. Standards (Part I, Metals, and Part II, Non-Metallic Materials) is available to other than members of the Society at $7.50 per copy for each part, or $14 for both parts. Individual standards are available separately. Requests for information or for publications should be addressed to American Society for Testing Materials, 1315 Spruce Street, Philadelphia, Pennsylvania.

Abrasion of Rock, Method of Test for: D 2-33.

Aggregate, Tentative Definition of the Term: C 58-28 T.
See also Surface Moisture
Unit Weight
Voids
Sieve Analysis
Specific Gravity
Coarse Aggregate
Mechanical Analysis
Stone
Concrete
Sand
Fine Aggregate.

Analysis (see Tests and Analysis).

Asphalt (see Sand).

Asphalt Block (see Cement Mortar Bed).
(See Asphalt Cement).

Asphalt Cement, 10 to 15 Penetration, for the Manufacture of Asphalt Block: D 133-23 T.

Asphalt Cement, 15 to 25 Penetration, for the Manufacture of Asphalt Block: D 134-23 T.

Asphalt Cement, 25 to 30 Penetration, for Use in Sheet Asphalt & Asphaltic-Concrete Pavements, D 163-23 T.

Asphalt Cement, 30 to 40 Penetration, for Use in Sheet Asphalt & Asphaltic-Concrete Pavements: D 164-23 T.

Asphalt Cement, 40 to 50 Penetration, for Use in Sheet Asphalt & Asphaltic-Concrete Pavements and as Filler for Brick and Block Pavements: D 99-26 T.

Asphalt Cement, 50 to 60 Penetration, for Use in Sheet Asphalt & Asphaltic-Concrete Pavements and as Filler for Block Pavements: D 100-26 T.

Asphalt Cement, 60 to 70 Penetration, for Use in Sheet Asphalt, Asphaltic-Concrete, and Asphalt-Macadam Pavements and as Filler for Block Pavements: D 101-26 T.

Asphalt Cement, 85 to 100 Penetration, for Use in Asphalt-Macadam Pavements: D 102-24 T.

Asphalt Cement, 100 to 120 Penetration, for Use in Asphalt-Macadam Pavements: D 103-24 T.

Asphalt Cement, 120 to 150 Penetration, for Use in Asphalt-Macadam Pavements: D 135-23 T.

Asphalt Cement (see also Road Oils).

Asphaltic Compounds (see Oil & Asphaltic Compounds).

Asphalt Filler for Brick Pavements (Blown Type): D 241-26 T.

Asphalt Macadam (see Asphalt Cement).

Asphalt Mastic for Use in Waterproofing: D 169-25.

Asphalt Pavement (see Mineral Filler).

Asphalts & Tar Pitches Sufficiently Solid to be handled in Fragments, Method of Test for Specific Gravity of: D 71-27.

Bar Steels, Commercial Quality, Hot-Rolled: A 107-33.

Barb Wire, Zinc-Coated (Galvanized) Iron or Steel: A 121-30.

Barb Wire, Zinc-Coated (Galvanized) Iron or Steel: A 121-32 T.

Base (see Broken Stone).
(see Slag).

Bed (see Cement Mortar Bed).

Bitumen, Method of Test for Determination of: D 4-27.

Bitumen, Method of Test for Determination of Proportion Soluble in Carbon Tetrachloride: D 165-27.

Bituminous Concrete.
(see Concrete Base)
(see Sand)
(see Slag)
(see Mineral Filler)
(see Stone)
(see Broken Stone).

Bituminous Coverings (see Curing Concrete).

Bituminous Emulsions, Methods of Testing: D 244-28 T.

Bituminous Macadam (see Slag).
(see Stone).

Bituminous Materials, Method of Test for Penetration of: D 5-25.

Bituminous Materials, Methods of Sampling: D 140-25.

Bituminous Materials, Method of Test for Ductility of: D 113-23 T.

Bituminous Materials, Method of Test for Softening Point of (Ring-and-Ball Method): D 36-26.

Bituminous Materials Suitable for Road Treatment, Method of Test for Distillation of: D 20-30.

Bituminous Materials, Method of Float Test: D 139-27.
Bituminous Paving Plant Inspection, Recommended Practice for: D 290-28 T.
Brick, Paving: C 7-30.
Brick Filler (see Cement Grout).
(see Asphalt Filler).
Brick Pavement (see Cement Mortar Bed).
Broken Stone, Certain Commercial Grades of: D 35-18.
Broken Stone & Broken Slag for Highway Construction, Commercial Sizes of: D 63-23 T.
Broken Stone for Waterbound Base: D 190-29 T.
Broken Stone for Bituminous Concrete Base: D 193-29 T.
Calcium Chloride Admixture (see Curing).
Calcium Chloride for Dust Prevention: D 98-30 T.
Calcium Chloride, Method of Chemical Analysis of: D 345-32 T.
Calcium Chloride, Surface Application of (see Curing).
Carbon-Steel Castings: A 27-24.
Castings (see Carbon-Steel Castings).
Castings, Gray-Iron: A 48-32 T.
Clay Sewer Pipe (Sizes 4 in. to 36 in.): C 13-32 T.
Cement, Natural: C 10-09.
Cement, Portland: C 9-30.
Cement, Portland, Methods of Sampling & Testing: C 77-32.
Cement Content of Hardened Portland-Cement Concrete, Method of Routine, Analysis of: C 85-31 T.
Cement Grout Filler for Brick & Stone Block Pavements: D 57-20.
Cement, High-Early-Strength Portland: C 74-30 T.
Cement Mortar Bed for Brick, Stone Block, Wood Block, Asphalt Block, and other Block Pavements: D 58-24.
Coal-Tar Pitch for Stone Block Filler: D 112-30.
Coarse Aggregates in a Saturated Condition, Method of Test for Apparent Specific Gravity of: C 86-31 T.
Coarse Aggregates, Method of Test for Apparent Specific Gravity of: D 30-18.
Coarse Aggregates, Method of Test for Soundness by Use of Sodium Sulfate: C 89-32 T.
Compression Tests of Concrete, Methods of Making: C 39-33.
Compression Test Specimens of Concrete, Method of Making & Storing in the Field: C 31-33.
Concrete (see Cement Content).
(see Portland Cement).
(see Curing).
Concrete Aggregates: C 33-31 T.
Concrete & Reinforced Concrete Work, Rules for Inspection of: C 44-22 T.
Concrete Base (see Gravel).
Concrete, Flexure Tests of (see Laboratory Method).
Concrete Reinforcement Bars, Billet-Steel: A 15-33.
Concrete Reinforcement Bars, Rail-Steel: A 16-33.
Concrete Reinforcement, Cold-Drawn Steel Wire for: A 82-33.
Concrete, Tar (see Tar-Cement).
Concrete Tests (see Compression Tests).
Concrete Test Specimens (see Hardened Concrete).
(see Compression Test Specimens).
Creosote (see Volume and Specific Gravity).
Creosote Oil, Methods of Sampling & Testing: D 38-33.
Creosote Oil, Method of Test for Distillation of: D 246-33.
Creosote Oil, Methods of Test for Insoluble Matter in: D 367-33.
Creosote Oil, Method of Test for Specific Gravity of: D 368-33.
Creosote Fractions, Method of Test for Specific Gravity, 38/15.5 C., of: D 369-33.
Creosote, Creosote Coal-Tar Solution (up to 50% tar) & Coal Tar (Coke Oven Tars), Volume & Specific Gravity Correction Tables for: D 347-33.
Creosote Oil, Method of Test for Water in: D 370-33.
Culvert Pipe, Cast Iron: A 142-32 T.
Culvert Pipe (see also Reinforced Concrete).
Curing Portland-Cement Concrete: C 80-31 T.
Curing Portland-Cement Concrete Slabs with Bituminous Coverings: C 81-31 T.
Curing Portland-Cement Concrete Slabs with Calcium Chloride Admixture: C 82-31 T.
Curing Portland-Cement Concrete Slabs by Surface Application of Calcium Chloride: C 83-31 T.
Curing Portland-Cement Concrete Slabs with Wet Coverings: C 84-31 T.
Definitions of Terms Relating to Materials for Roads & Pavements: D 8-33.
Definitions of Terms Relating to Specific Gravity: E 12-27.
Drain Tile (4 in. to 42 in. diameter): C 4-24.
Durax Granite Pavements, Block for: D 132-23.
Dust Prevention (see Calcium Chloride).
Emulsions (see Bitumens).
Fence Fabric, Zinc-Coated Iron or Steel Chain-Link, Galvanized after Weaving: A 117-33.
Fence Fabric, Zinc-Coated Iron or Steel Chain-Link, Galvanized after Weaving: A 117-32 T.
Fencing (see Wire Fencing).
Filler (see Asphalt Cement).
(see Mineral Filler).
Fine Aggregate Using Constant Water-Cement-Ratio Mortar, Method of Test for Structural Strength of: C 87-32 T.
Fine Aggregates, Method of Test for Soundness by Use of Sodium Sulfate: C 88-32 T.
Fine Aggregate (see Aggregate).
Flexure Tests of Concrete (see Laboratory Method).
Granite Block (see Recent Granite Block).
(see Durax).
Granite Block Filler (see Cement Grout).
Granite Block Pavement (see Cement Mortar Bed).
Granite Block Pavements, Block for: D 59-26.
Grout (see Cement Grout).
Gravel (see Sand).
Gravel for Bituminous Concrete Base: D 309-30.
Gravel for Highway Construction, Method of Test for Quantity of Clay and Silt in: D 72-21.
Gravel, Method of Test for Abrasion of: D 289-28 T.
Hardened Concrete, Methods of Securing Specimens from the Structure: C 42-31.
High-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product): D 106-28 T.
High-Early-Strength Cement (see Cement).
Inspection (see Bituminous Paving Plant).
Inspection Rules (see Concrete & Reinforced Concrete).
Laboratory Method of Making Flexure Tests of Concrete, Using a Simple Beam with Center Loading: C 78-30 T.
Low-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product): D 107-28 T.
Lumber (see Structural Wood).
Macadam (see Tar-Cement).
(see Stone).
Mineral Filler for Sheet Asphalt & Bituminous Concrete Pavements: D 242-26 T.
Mixtures of Sand or Other Fine Material with Broken Stone or Broken Slag, except Aggregates Used in Cement-Concrete, Method of Mechanical Analysis of: D 19-16.
Moisture Equivalent of Sub-Grade Soils, Method of Test for the Determination of, in the Field: D 220-29.

Oil & Asphaltic Compounds, Method of Test for Loss on Heating of: D 6-33.
Organic Impurities in Sands for Concrete, Method of Test for: C 40-33.
Paving Brick (see Brick).
Petroleum Products (see Water and Sediment).
Piles, Timber: D 25-30 T.
Pipe (see Clay Sewer Pipe).
(see Culvert Pipe).
(see Sewer Pipe).
(see Reinforced Concrete).
Portland Cement (see Cement).
Portland-Cement Concrete, Method of Test for Consistency of: D 138-32 T.
Posts (see Structural Wood).
Preservatives (see Timber).
Recut Granite Block Pavements, Block for: D 131-23.
Reinforcement (see Concrete Reinforcement).
Reinforced-Concrete Pipe (Sizes 24 in. to 108 in.): C 75-30 T.
Reinforced-Concrete Culvert Pipe (Sizes 12 in. to 84 in.): C 76-30 T.
Repair Work (see High-Carbon Tar).
(see Low-Carbon Tar).
Residue of Specified Penetration, Method of Test for: D 243-32 T.
Rivets (see Structural Rivet Steel).
Road Oils, Road Tars, Asphalt Cements, and Soft Tar Pitches, Method of Test for Specific Gravity of: D 70-27.
Rock, Method of Test for Toughness of D 3-18.
Rolled & Forged Steel Products, Methods of Sampling for Check Analysis: A 130-30.
Round Hole Screens for Testing Purposes: E 17-31 T.
Sampling
See—Bituminous Materials
Stone, Slag, Gravel, and Stone Block
Creosote Oil
Cement
Compression Test Specimens
Hardened Concrete
Rolled and Forged Steel Products.
Sand (see Stone).
Sand, Definition of the Term: C 58-28.
Sand, Impurities in (see Organic Impurities).
Sand & Gravel for Highway Construction, Commercial Sizes of: D 64-20 T.
Sand & Other Fine Aggregates, Method of Decantation Test for: D 136-28.
Sand or Other Fine Highway Material, except Fine Aggregates Used in Cement Concrete, Method of Mechanical Analysis of: D 7-27.
Sand for Sheet Asphalt & Bituminous Concrete Pavements: D 162-29.
Sand, Stone & Slag Screenings, and Other Fine Non-Bituminous Highway Materials, Methods of Test for Apparent Specific Gravity of: D 55-25.
Screen (Sieve), Tentative Definition of the Term: E 13-28 T.
Screen (see Sieve).
Screens, Round-Hole, for Testing Purposes: E 17-33.
Screens (see Round-Hole).
Screenings (see Sand).
Sewer Pipe, Cement-Concrete (4 in. to 42 in. not reinforced): C 14-24.
Sewer Pipe (see Clay Sewer Pipe).
Sheet Asphalt (see Asphalt).
Sieve (see Screen).
Sieve Analysis of Aggregate for Concrete (No. 100 to 3 in.), Method of Test for: C 41-33.
Sieves for Testing Purposes: E 11-26.
Slag (see Stone).
Slag, Broken, for Bituminous Concrete Base: D 196-27.
Slag, Broken, for Bituminous Concrete (Coarse-Graded Aggregate Type): D 160-27.
Slag, Broken, for Bituminous Concrete (Fine-Graded Aggregate Type): D 161-27.
Slag, Broken, for Bituminous Macadam Base: D 195-27.
Slag, Broken, for Bituminous Macadam Wearing Course: D 159-27.
Slag, Broken, for Waterbound Base & Wearing Course: D 65-23.
Slag, Broken, Shovel-Run or Crusher-Run for Waterbound Base: D 66-23.
Slag, Mechanical Analysis of (see Stone or Slag).
Soundness Test (see Fine Aggregate).
Specific Gravity (Approximate Apparent) of Fine Aggregate, Method of Test for: C 68-30.
Specific Gravity, 38 degrees/15.5 degrees C., of Creosote Fractions, Method of Test for the Determination of: D 38-30 T.
Specific Gravity (see Definition).
Specific Gravity of Aggregate (see Coarse Aggregate).
Steel (see Structural Steel).
(see Rolled and Forged Steel Products).
Steel Suitable for Fusion Welding: A 151-33.
Stone (see Broken Stone).
Stone Block (see Granite Block).
(see Stone).
Stone Block Filler (see Coal-Tar Pitch).
Stone, Broken, for Bituminous Concrete Surface: D 194-29.
Stone, Broken, for Bituminous Macadam: D 192-29.
Stone, Broken, for Waterbound Macadam Surface Course: D 191-29.
Stone, Slag, Gravel, Sand and Stone Block, for Use as Highway Materials, Methods of Sampling (including some Material Survey Methods): D 75-22.
Stone or Slag (Broken) Except Aggregates Used in Cement-Concrete, Method of Mechanical Analysis of: D 18-16.
Structural Medium Steel: A 140-32 T.
Structural Rivet Steel: A 141-32 T.
Structural Rivert Steel: A 141-33.
Structural Silicon Steel: A 94-33.
Structural Steel for Bridges: A 7-33.
Structural Wood Joists & Planks, Beams & Stringers, and Posts & Timbers: D 245-33.
Sub-Grade Soils (see Moisture).
Surface Treatment (see Tar).
(see Tar-Cement).
Surface Moisture in Fine Aggregate, Method of Test for C 70-30.
Tar (see High-Carbon Tar).
(see Low-Carbon Tar).
(see Road Oil).
(see Volume and Specific Gravity).
Tar for Surface Treatment, Low Carbon, Hot Application: D 109-30.
Tar-Cement, High Carbon (suitable for use in the construction of tar macadam and tar concrete pavements): D 110-30.
Tar-Cement, Low Carbon (suitable for use in the construction of tar macadam and tar concrete pavement): D 111-30.
Tar for Surface Treatment, High Carbon, Cold Application: D 104-30.
Tar for Surface Treatment, Low Carbon, Cold Application: D 105-30.
Tar for Surface Treatment, High Carbon, Hot Application: D 108-30.

Tar Pitch (see Asphalt).
(see Road Oils).
Tar Products, Method of Test for Softening Point of: (Cube-in-Water Method): D 61-24.
Tests (see Material by name).
Tests and Analyses
See—Gravel
Portland-Cement Concrete
Calcium Chloride
Bituminous Materials
Residue of Specified Penetration
Bituminous Emulsion
Specific Gravity
Volume and Specific Gravity
Round-Hole Screens
Screen
Coarse Aggregate
Fine Aggregate
Laboratory Method
Cement Content
Tar Products
Sand, Stone and Slag
Asphalts and Tar Pitches
Road Oils, Road Tars, Asphalt, Cements and Soft Tar Pitches
Rock
Abrasion of Rock
Bitumen
Sand and Other Aggregates
Oil and Asphaltic Compounds
Stone or Slag
Mixture of Sand, etc.
Sand or Other Fine Highway Material
Moisture Equivalent
Creosote Oil
Water and Sediment
Zinc Chloride
Cement
Compression Test Specimens
Compression Tests
Organic Impurities
Sieve Analysis
Surface Moisture
Unit Weight of Aggregate
Voids in Fine Aggregate
Voids in Inundated Fine Aggregate
Timber.
Tile (see Drain Tile).
Timber (see Structural Wood).
(see Piles).
Timber, Definitions of Terms Relating to: D 9-30.
Timber, Method of Testing Small Clear Specimens of: D 143-27.
Timber Preservative, Definition of Terms: D 324-33.
Timber Preservatives, Definitions of Terms Relating to: D 324-30 T.
Timbers in Structural Sizes, Methods of Conducting Static Tests of: D 198-27.
Unit Weight of Aggregate for Concrete, Method of Test for: C 29-27.
Voids in Fine Aggregate for Concrete, Method of Test for Determination of: C 30-22.
Voids in Inundated Fine Aggregate, Method of Test for Approximate Percentage of: C 69-30.
Volume & Specific Gravity Correction Tables for Creosote, Creosote Coal-Tar Solution (up to 50 per cent Tar) and Coal Tar (Coke Oven Tars): D 347-32 T.
Water & Sediment in Petroleum Products, Method of Test by Means of Centrifuge: D 96-30.
Waterbound Base (see Broken Stone).
(see Slag).
Waterbound Macadam (see Stone).
Waterproofing (see Asphaltic Mastic).
Water-Cement Ratio (see Fine Aggregate).
Wearing Course (see Slag).
Wet Coverings (see Curing).
Wire (see Barb Wire).
(see Zinc-Coated Wire and Wire Products).
Wire Fencing, Zinc-Coated (Galvanized) Iron or Steel Farm-Field & Railroad Right-of-Way: A 116 30.
Wire Fencing, Zinc-Coated (Galvanized) Iron or Steel Farm-Field and Railroad Right-of-Way: A 116-32 T.
Wire Reinforcement (see Concrete Reinforcement).
Wire Strand (Cable), Zinc-Coated (Galvanized) Iron or Steel: A 122-33.
Wire Strand (Cable), Zinc-Coated (Galvanized) Iron or Steel: A 122-32 T.
Wood (see Structural Wood).
Wood Block Pavement (see Cement-Mortar Bed).
Wooden Paving Blocks for Exposed Pavements: D 52-20.
Zinc Chloride, Methods of Chemical Analysis: D 199-27.
Zinc-Coated (Galvanized) Iron & Steel Wire & Wire Products, Standard Methods of Testing: A 110-30.

Specifications of the National Societies and Associations

Many specifications are issued by technical societies, trade associations, and other bodies of nationally recognized standing. Important among them are the following:

Brick Pavement.—Detailed specifications for paving brick and brick pavement construction, by National Paving Brick Manufacturers' Association, 1245 National Press Building, Washington, D. C.

Stone Block Pavement.—Detailed specifications for stone paving blocks and stone block pavement construction, by American Society of Municipal Engineers, 4359 Lindell boulevard, St. Louis, Missouri.

Asphalt Pavements.—Detailed specifications for materials and construction of sheet asphalt and other types of asphalt pavement, by The Asphalt Institute, 801 Second Avenue, New York, N. Y., and 206 Sansome Street, San Francisco, California.

Concrete Pavement.—Detailed specifications for materials and construction of concrete pavements, by Portland Cement Association, 33 West Grand Avenue, Chicago, Illinois.

Specifications for Bridges and Incidental Structures, A. A. S. H. O.

The American Association of State Highway Officials' "Standard Specifications for Highway Bridges and Incidental Structures" is a 236-page volume issued in 1931. General offices of the Association are located in the National Press Building, Washington, D. C.

The specifications are divided into five major parts as follows: I. General Provisions, II. Materials, III. General Construction, IV. Special Construction, and V. Design.

Section titles under Division III, General Construction are:

Highway Materials Specifications of the American Association of State Highway Officials

Highway materials standards of the American Association of State Highway Officials are all issued as tentative, under the title, "Tentative Standard Specifications for Highway Materials and Methods of Sampling and Testng." The latest complete edition is that of 1931, but this is supplemented by a pamphlet of revision adopted in 1933. The general offices of the Association are located in the National Press Building, Washington, D. C. Following is a table of contents of the volume of specifications and the revisions.

Part I—Tentative Standard Specifications for Materials

Specification No.	TITLE.
M-1	Specification for Stone for Telford Base Course and Reconstructed Base Course.
M-2	Specification for Broken Stone for Waterbound Base Course.
M-3	Specification for Broken Slag for Waterbound Base Course.
M-4	Specification for Broken Stone for Bituminous Concrete Base Course.
M-5	Specifications for Portland Cement.
M-6	Specification for Fine Aggregate for Portland Cement Concrete Pavement or Base Course, Highway Bridges and Incidental Structures.
M-6a	Specification for Mortar Sand.
M-7	Specification for Broken Stone for Portland Cement Concrete Base Course.
M-9	Specification for Broken Stone for Waterbound Macadam Surface Course.
M-10	Specification for Broken Slag for Waterbound Surface Course.
M-11	Specification for Broken Stone for Bituminous Macadam Surface Course.
M-12	Specification for Broken Slag for Bituminous Macadam Surface Course.
M-13	Specification for Broken Stone for Bituminous Concrete Surface Course.
M-14	Specification for Broken Slag for Bituminous Concrete Surface Course.
M-15	Specification for Broken Stone for Portland Cement Concrete Surface Courses, Highway Bridges and Incidental Structures.
M-16	Specification for Broken Slag for Portland Cement Concrete Base and Surface Course.
M-17	Specification for Mineral Filler.
M-18	Specification for Oil Asphalt Filler, Type A.
M-19	Specification for Asphalt Filler, Type B.
M-20	Specification for Asphalt Cement (Prepared from Petroleum).
M-21	Specifications for Asphalt Cement (Prepared from Petroleum).
M-22	Specification for Asphalt Cement (Prepared from Native Asphalt).
M-23	Specification for Asphalt Cement (Prepared from Native Asphalt).
M-24	Specification for Tar for Surface Treatment (Cold Application).
M-25	Specification for Tar for Surface Treatment (Hot Application).
M-26	Specification for Tar for use in the Maintenance of Cracks and for Sealing Joints in Concrete Roads.
M-27	Specification for Tar Cement.
M-29	Specification for Sand for Bituminous Mixtures.
M-30	Specification for Wire Rope and Fittings for Highway Guard Rail.
M-31	Specification for Billet-Steel Concrete Reinforcement Bars.
M-32	Specification for Cold Drawn Steel Wire Fabric for Concrete Reinforcement.
M-33	Specification for Premolded Expansion Joints.
M-34	Specification for White Traffic (Zone) Paint (Ready Mixed) for Brick and Bituminous Pavements.
M-35	Specification for White Traffic (Zone) Paint (Ready Mixed) for Concrete Pavements.
M-36	Specification for Base Metal for Corrugated Metal Sheets for Culverts.
M-37	Specification for Gravel for Portland Cement Concrete Pavements or bases, Highway Bridges and Incidental Structures.
M-38	Specification for Asphalt Emulsion (Slow breaking type).
M-39	Specification for High-Early-Strength Cement.
M-40	Specifications for Paving Brick.
M-41	Specifications for Reinforced Concrete Culvert Pipe.
M-42	Specifications for Rail Steel Concrete Reinforcement Bars.

Part II—Tentative Standard Methods of Sampling and Testing Highway Materials

Specification No.	TITLE.
T-1	Methods of Testing Cement.
T-2	Methods of Sampling Stone, Slag, Gravel, Sand, and Stone Block for use as Highway Materials, including some Material-Survey Methods.
T-3	Method of Test for Abrasion of Broken Stone and Broken Slag.
T-4	Method of Test for Abrasion of Gravel.
T-5	Method of Test for Toughness of Rock.
T-6	Method of Test for Toughness of Gravel.
T-7	Method of Determining Quality of Glacial Gravels by Lithological Count of Particles.
T-8	Method of Test for Quality of Soft Pebbles in Gravel.
T-9	Method of Test for Soundness of Coarse Aggregate.
T-10	Method of Test for Percentage of Shale in Aggregate.
T-11	Method of Test for Quantity of Clay and Silt in Gravel (for highway construction).
T-12	Method of Decantation Test for Sand and other fine Aggregates.
T-13	Method of Test for Apparent Specific Gravity of Sand, Stone, and Slag Screenings, and other fine non-bituminous highway materials.
T-14	Method of Test for Apparent Specific Gravity and Absorption of Stone and other Coarse Materials.
T-15	Method of Test for Apparent Specific Gravity and Absorption or Free Moisture Content of Sand, Gravel, Stone, or Other non-bituminous Highway Materials.
T-16	Method of Test for Approximate Apparent Specific Gravity of Fine Aggregate.
T-17	Method of Test for Approximate Percentage of Voids in Inundated Fine Aggregate.
T-18	Method of Test for Surface Moisture in Fine Aggregate.
T-19	Method of Test for Unit Weight of Aggregate for Concrete.
T-20	Method of Test for Determination of Voids in Fine Aggregate for Concrete.
T-21	Method of Test for Organic Impurities in Sand for Concrete.
T-22	Method of Making Compression Tests of Concrete.
T-23	Method of Making and Storing Compression Specimens of Concrete in the Field.
T-24	Methods of Securing Specimens of Hardened Concrete from the Structure.
T-25	Method of Test for Absorption of Concrete.
T-26	Method of Test for Quality of Water to be used in Concrete.
T-27	Method of Test for Sieve Analysis of Aggregates for Concrete.
T-28	Method of Mechanical Analysis of Sand or other Fine Highway Materials.
T-29	Method of Mechanical Analysis of Coarse Aggregates.
T-30	Method of Mechanical Analysis of Extracted Aggregates.
T-31	Methods of Sampling and Testing Paving Brick.
T-32	Methods of Testing Brick (Compression, Flexure and Absorption).
T-33	Methods of Testing Culvert Pipe.
T-34	Method of Sampling and Testing Drain Tile.
T-35	Methods of Making Compression and Tension Tests of Fine Aggregate for Concrete.
T-36	Method of Sampling Mineral Filler.
T-37	Method for Determination of Fineness of Mineral Filler.
T-38	Method of Proportioning Natural Sand and Gravel for Concrete Construction.
T-39	Methods of Tests for Wire Rope (Guardrail).
T-40	Methods of Sampling Bituminous Materials.
T-41	Methods of Sampling Bituminous Mixtures.
T-42	Methods of Sampling and Testing Premolded Joint Fillers.
T-43	Methods of Test for Specific Gravity of Bituminous Materials.
T-44	Method of Test for Percentage of Bitumen (Soluble in Carbon Disulphide).
T-45	Method of Test for Percentage of Bitumen Insoluble in Carbon Tetrachloride.
T-46	Method of Test for Percentage of Bitumen Insoluble in Paraffin Naphtha.
T-47	Method of Test for Loss on Heating of Oil and Asphaltic Compounds.
T-48	Method of Test for Flash and Fire Points by Means of Open Cup.
T-49	Method of Test for Penetration of Bituminous Materials.
T-50	Method of Float Test for Bituminous Materials.
T-51	Method of Test for Ductility of Bituminous Materials.
T-52	Method of Test for Distillation of Tars and Tar Products.
T-53	Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method).
T-54	Method of Test for Specific Viscosity.
T-55	Method of Test for Water in Petroleum Products and Other Bituminous Materials.
T-56	Method of Test for Percentage of Residue of Desired Penetration.
T-57	Calcium-Chloride Method for Determination of Percentage of Water in Bituminous Emulsions.
T-58	Method for Examination of Bituminous Mixtures (Centrifugal Method).
T-59	Methods of Testing Bituminous Emulsions.
T-60	Methods of Sampling and Analysis of Creosote Oil.
T-61	Method of Test for Coke Residue of Creosote Oil.
T-62	Method of Test for Distillation of Creosote Oil.
T-63	Method of Sampling and Testing Wood Block.
T-64	Method of Test and Inspection of Corrugated Metal Culvert.
T-65	Methods of Determining Weight of Coating on Zinc-Coated Articles.
T-66	Method of Test for Uniformity of Galvanizing or Spelter Coating on Wire.
T-67	Methods of Verification of Testing Machines.
T-68	Methods of Tension Testing of Metallic Materials.
T-69	Methods of Compression Testing of Metallic Materials.
T-71	Method of Test for Sand to be Used as Fine Aggregate in Concrete.
T-72	Methods of Test for Viscosity of Petroleum Products and Lubricants.
T-73	Method of Test for Flash Point by Means of the Pensky-Martens Closed Tester.
T-74	Method of Test for the Determination of the Specific Gravity, 38°/15.5° C., of Creosote Fractions.

Glossary of Terms Used in Road and Street Work

Who has not suffered loss or inconvenience through lack of an exact definition for a term in a specification or other legal instrument—or perhaps even in some entirely non-legal usage? It is impractical to carry many such definitions in one's head; dictionaries are unsatisfactory in technical matters; and the printed definitions we might like to use are apt to be in uncertain and inaccessible places.

The glossary here given, while far from complete, is wider in scope than most glossaries, or sets of definitions, and will, we believe, afford an exceedingly convenient source of reference to owners of the Road and Street Catalog. Its sources are as follows:

Definitions followed by an asterisk (*) are those recommended by the American Society of Civil Engineers. Definitions followed by a dagger (†) are from the asphalt road construction manual issued in 1933 by The Asphalt Institute. While compiled primarily for users of asphalt, they cover many subjects of equal importance in other forms of road construction. Definitions with no following mark are taken from the manual of the Ohio Department of Highways and Public Works.

Abrasion—The act of wearing or rubbing off or away by friction or attrition.

Abutment—A supporting wall carrying the end of a bridge or span and sustaining the pressure of the abutting earth. The abutment of an arch is commonly called a bench wall.

A. C. B.—Asphalt Cut Back—A heavy asphalt fluxed with naphtha to reduce viscosity. It is liquid at low temperature, but when mixed with aggregate and exposed to the air rapidly loses its fluxing agent, leaving a viscous matrix.

A. E.—Asphalt Emulsion—A mixture of asphalt and water which has an emulsifying agent incorporated. The consistency can be modified by the addition of soft water. The emulsion is broken by agitation, such as mixing with stone or by chemical action of either acid or base, or by physical action of mixture with dust. The asphalt is precipitated, leaving water content free.

Aggregate—The mineral material, such as sand, gravel, shells, slag, or broken stone, or combinations thereof, with which the cement, or the bituminous material is mixed to form a mortar or concrete. *Fine aggregate* may be considered as the mineral inert material which will pass a one-fourth inch screen, and *coarse aggregate* the material which will not pass a one-fourth inch screen.*

Annealed—Subjected to a high heat and cooled by a gradual process for the purpose of softening and rendering less brittle.

Approach Slab—A reinforced concrete slab spanning the backfill behind the abutment.

Arch—A curved structural member which spans an opening and supports the adjacent members by resolving vertical pressure into horizontal or diagonal thrust. *Arch Bridge*—A bridge whose main members are arches. *Bow String Arch*—An arch having a bottom chord. *Filled Spandrel Arch*—An arch bridge, the roadway of which is supported by a fill of earth or other material over the arch ring. *Open Spandrel Arch*—An arch bridge, the roadway of which is supported by columns from the arch rib. *Through Arch*—An arch bridge, the roadway of which is below the crown of the arch. *Arch Rib*—An arch member of a bridge in cases where the roadway is supported by two or more separate arches per span. *Arch Ring*—The arch member of a bridge in cases where the roadway is supported by a single arch for each span.

Armor Coat—A variety of surface treatment principally used in the Pacific Coast States on any sound prepared base, usually of traffic-bound type. It is essentially a double surface treatment composed of a light application of hot asphalt on a primed base, the application of asphalt and finally a seal coat of small-sized crushed aggregate and a light application of asphalt.†

Arris—The external edge formed by two surfaces, whether plane or curved, meeting each other.

Asphalt—Semi-solid or solid, black, sticky residue formed by the partial evaporation of certain natural bitumens. This applies to asphalts occurring as such in nature and those obtained by refining petroleum.†

Asphalt—Solid or semi-solid native bitumens, solid or semi-solid bitumens obtained by refining petroleums, or solid or semi-solid bitumens which are combinations of the bitumens mentioned with petroleums or derivatives thereof, which melt on the application of heat, and which consist of a mixture of hydrocarbons and their derivatives of complex structure, largely cyclic and bridge compounds.*

Asphalt Block Pavement—One having a wearing surface of previously prepared blocks of asphaltic concrete.*

Asphalt Cement—A fluxed or unfluxed asphaltic material, especially prepared as to quality and consistency, suitable for direct use in the manufacture of asphaltic pavements, and having a penetration of between 5 and 250.*

Asphalt Cutbacks—See cutback asphalts.

Asphalt (Emulsified)—Asphalt cement which has been combined with a small amount of soap-forming constituents or other emulsifying agent, and with water, so that the mixture may be brought to any degree of fluidity by the further addition of water. Upon exposure to atmospheric conditions, the water evaporates after which the asphalt cement left behind will not ordinarily again mix with water under conditions of use.†

Asphaltenes—The components of the bitumen in petroleum products, malthas, asphalt cements, and solid native bitumens, which are soluble in carbon disulphide, but insoluble in paraffin naphthas.*

Asphaltic—Similar to, or essentially, composed of asphalt.*

Asphalt Primer—A liquid asphaltic product of low viscosity particularly designed for high penetration into dusty surfaces. Specification for liquid asphaltic road material MC-1 specifies such a primer, which develops an asphalt cement content shortly after application, due to a process of selective absorption of solvent oils.†

Axis—A line around which the parts of a body or system are symmetrically arranged.

Back Wall—A wall projecting from the bridge seat to the top of the earth fill, to prevent the earth from flowing onto the bridge seat, and to support the approach slab.

Base Plate—Plate upon which a rocker or roller rests.

Batter—The slope or inclination of the face or back of a wall from a vertical plane.

Batter Pile—One driven at an inclination to resist forces which are not vertical.

Base—An artificial foundation.*

Berm—That portion of the roadway extending from the edge of the pavement to the inside of the ditch.

Billet Steel—Steel cast in billet form, either by the Bessemer or open hearth process. Does not include high carbon or rerolled steel.

Binder—a foreign material introduced into the mineral portion of the wearing surface for the purpose of assisting the road metal to retain its integrity under stress, as well as, perhaps, to aid in its first construction. (2) The course, in a sheet-asphalt pavement, frequently used between the concrete foundations and the sheet-asphalt mixture of graded sand and asphalt cement.*

Bitumen—A mixture of native or pyrogenous hydrocarbons and their non-metallic derivatives which may be gases, liquids, viscous liquids, or solids, and which are soluble in carbon disulphide.*

Bituminous Cement—A bituminous material suitable for use as a binder, having cementing qualities which are dependent mainly on its bituminous character.*

Bituminous Concrete Pavement—One composed of stone, gravel, sand, shell, or slag, or combinations thereof, and bituminous materials incorporated together by mixing methods.*

Bituminous Concrete Pavement—One composed of broken stone, broken slag, gravel, or shell, with or without sand, portland cement, fine inert material, or combinations thereof, and a bituminous cement incorporated together by a mixing method.

Bituminous Macadam Pavement—A pavement having a wearing course of macadam with the interstices filled by a penetration method with a bituminous binder.

Bituminous Macadam Pavement—One having a wearing course of macadam with the interstices filled by penetration methods with a bituminous binder.*

Bituminous Material—Material containing bitumen as an essential constituent.*

Bituminous Material, Liquid—Bituminous material showing a penetration at normal temperature under a load of 50 grammes applied for one second or more than 350.*

Bituminous Material, Semi-Solid—Bituminous material showing a penetration at normal temperature under a load of 100 grammes applied for one second of not more than 350.*

Bituminous Material, Solid—Bituminous material showing a penetration at normal temperature under a load of 100 grammes applied for five seconds of not more than 10.*

Bituminous Pavement—One composed of stone, gravel, sand, shell, or slag, or combinations thereof, and bituminous materials incorporated together.*

Bituminous Surface—A superficial coat of bituminous material with or without the addition of stone, or slag chips, gravel, sand, or materials of similar character.*

Bituminous Surface Treatments—A general term employed to describe all surface treatments accomplished with bituminous materials, for the purpose of hardening, evening, and waterproofing the surface.†

Bleeding—The exudation of bituminous material on the pavement surface after construction.*

Blotter Treatment—A variety of surface treatment used principally on natural earth subgrades which have been carefully prepared by blading; and on which an application of asphalt is made followed by a coating of graded aggregate, such as sandy gravel, which blots up a part of the asphalt previously applied and, when dragged, forms a thin asphalt-aggregate mulch over the subgrade surface.†

Blown Petroleums—Semi-solid or solid products produced primarily by the action of the air upon originally fluid native bitumens which are heated by the blowing process.*

Bolster—A casting supporting the fixed end of truss or girder.

Bond—The combined action of inertia, friction, and of the forces of adhesion and cohesion which helps the separate particles composing a crust or pavement to resist separation under stress. Mechanical bond is the bond produced almost wholly, in well-built broken-stone macadam road, by the interlocking of angular fragments of stone and the subsequent filling of the remaining interstices with the finer particles.*

Bound—Bonded.* *Water-Bound*—Bonded with the aid of water.* *Bituminous Bound*—Bonded with the aid of bituminous material.*

Breast Wall—A wall built to prevent the falling of a vertical face cut into natural soil.

Brick Pavement—One having a wearing course of paving bricks or blocks.*

Bridge—A structure for carrying traffic over a stream or gully, the paving material or wearing course resting directly on the floor of the structure.

Bridge—A structure for the purpose of carrying traffic over a gap in the road-bed measuring ten feet or more in the clear span.*

Bulkhead—A partition or form used for shutting off a part of given space.

Bulking—The separation of the particles and increased volume of aggregate due to the presence of a small per cent of water.

Bumpometer—A straight edge equipped with wheels and an electric signaling device for testing the smoothness of pavements.

Buttress—A vertical projecting piece of masonry built in front of a wall to strengthen it.

Caliche—A material found in the southwest, principally in Texas, which is a clay containing a high percentage of lime or a soft limestone rock containing a large amount of clay. In either case, the material is easily broken up into small particles and readily consolidated into an amorphous mass under water-action and blading. It has a great affinity for water.†

Camber—The rise of the center of a bridge or structural member above a straight line through its ends.

Camber of a Bridge—The rise of its center above a straight line through its ends.*

Camber of a Road—See *Crown.**

Carbenes—The components of the bitumen in petroleums, petroleum products, malthas, asphalt cements, and solid native bitumens, which are soluble in carbon disulphide, but which are insoluble in carbon tetrachloride.*

Carpet—A bituminous surface of appreciable thickness, generally formed on top of a roadway by the application of one or more coats of bituminous material with gravel, sand, or stone chips added.*

Carpet Coat—Another general term employed in practically the same sense as mat coat.†

Catch Basin—A receptacle for diverting surface water to an underdrain, having at its base a sediment bowl.

Caulk—To fill seams or joints in such manner as to prevent leaking.

Cement—An adhesive substance used for uniting particles of other materials to each other. Ordinarily applied only to calcined "cement rock," or to artificially

prepared calcined and ground mixtures of limestone and silicious materials. Sometimes used to designate bituminous binder used in bituminous pavements, when the expression "bituminous cement" (q.v.) is understood to be meant.*

Cement Concrete—An intimate mixture of gravel, shell, slag, or broken-stone particles with certain proportions of sand or similar material, cement and water, made previous to placing.*

Cement Concrete Pavement—One having a wearing course of hydraulic cement concrete.*

Cemented—Bonded. Referring to water-bound macadam, the term "cemented" is used to designate that condition existing when, after rolling the stone forming the crust, the remaining voids have filled with the finer sizes, and the stone dust or "flour" has, under the action of water, taken a "set" as does cement itself.*

Cement Gun—A trade name applied to an apparatus used for the placing of mortar under pressure, the characteristics being that the mortar is forced dry to the nozzle, hydration taking place at the nozzle, and coincident with the application.

Center and Centering (for arches)—False work for an arch.

Chats—A material found principally in the middle west, being the tailings from mills in which zinc, silver, lead and other ores are separated from the rocks in which they occur. In reality, chats are a variety of crushed stone obtained as a by-product from metal mining.†

Chert—A sedimentary silicious material found naturally in many parts of the country, formed of chalcedonic or opeline silica or both—the cubical particles ranging in size from one to one and one-half inches in dimension down to and including dust. When placed on a roadway and thoroughly dragged, it has high interlocking qualities, due to the shape and toughness of the particles.†

Chips—Small angular fragments of stone or slag containing no dust.

Chips—Small angular fragments of stone containing no dust.*

Cinders—Cinders are of a variety of kinds according to whether they are the product of anthracite coal or bituminous coal. In general, bituminous coal cinders have a more granular character and make the better surfacing. They are usually employed as an admixture to existing roadbeds and are combined with the underlying soil to produce greater stability.†

Clay—Finely divided earth, generally silicious and aluminous, which will pass a 200-mesh sieve. Also see *Gravel.**

Clay-Gravel—Gravel which, in addition to the smaller-sized particles of silica, contains a percentage of clay so that under the puddling action of the drag, a certain cementitiousness is developed which produces a dense, firm surface.†

C. O.—Cold Oil—Asphalt fluxed with 22 per cent to 30 per cent of naphtha, so that it can be applied cold.

Coal-Tar—The mixture of hyrocarbon distillates, mostly unsaturated ring compounds, produced in the destructive distillation of coal.*

Coat—See *Carpet.* (1) The total result of one or more single surface applications. (2) To apply a coat.*

Cofferdam—An enclosure built in the water, and then pumped dry, so as to permit masonry or other work to be carried on inside of it.

Coke-Breeze—A product found in limited amount adjacent to beehive ovens used in the manufacture of coke. Coke-Breeze is the residue of small, fragmentary particles of coke not large enough for commercial use. It is used to produce a surface in a manner similar to cinders.

Coke-Oven Tar—Coal-tar produced in by-product coke ovens in the manufacture of coke from bituminous coal.*

Consistency—The degree of solidity or fluidity of bituminous materials.*

Consistency—The degree of solidity or fluidity of materials.

Coping—A top course of stone or concrete, generally slightly projecting, to shelter the masonry from the weather, or to distribute the pressure from exterior loading.

Counterfort—Vertical projections in reinforced masonry built along the back of a wall to strengthen it.

Counter Sink—To cut away material from the edge of a hole in such manner that the head of a screw, rivet or bolt will be flush with the surface.

Course—One or more layers of road metal spread and compacted separately for the formation of the road or pavement. Courses are usually referred to in the order of their laying, as first course, second course, third course, etc. Also a single row of blocks in a pavement.*

Creep—A slow, natural downward movement of loose material on hillsides.

Creosoting Oil—Tar distillates, tars and mixtures of tars with tar distillates which are used by a process of impregnation in the preservation of wood. Note: This term was originally confined to the heavier coal-tar distillates carrying a large proportion of the creosols which were present in the tar before distillation.

Crown—Highest point on cross-section, usually the center.

Crown—(of an Arch)—The highest point of an arch rib or ring.

Crown—The rise in cross-section from the lowest to the highest part of the finished roadway. It may be expressed either as so many inches (or tenths of a foot), or as a rate per foot of distance from side to center—that is, "the crown is four inches," or "the crown is one-half inch to the foot."*

Crusher Run—The total unscreened product of a stone crusher.*

Crusher Run Stone—The product of a stone crusher, unscreened except for the removal of the particles smaller than remaining on about a one-fourth inch screen.*

Crust—That portion of a macadam or similar roadway above the foundation consisting of the road metal proper with its bonding agent or binder.*

Cutback Asphalts—Liquid asphalt products made by combining asphalt cements with lighter distillates.†

C.-T.—Cold Tar—Tar fluxed with some of the lighter distillates, so that it can be applied cold.

Culvert—Roadway structure of a span of more than one foot, designing to support a super-imposed load of earth or other filling material.

Culvert—A structure for the purpose of carrying traffic over a gap in the road-bed, measuring less than ten feet in clear span.*

Cutback Asphalts, Medium-Curing—These are liquid asphalt products in which the period of hardening or curing is somewhat retarded. Liquid asphaltic road material MC-1 for priming is of this type. These cutbacks have a unique and distinctive property, namely, high penetrative qualities and ability to take up dust rapidly and completely, followed by selective

absorption of the distillate from the mixture which leaves the asphalt cement distributed through the upper surface.†

Cutback Asphalts, Quick-Curing—These are liquid asphalt products which have the property of hardening or curing rapidly after application. Specification for liquid asphaltic road material RC-1 for seal coat is of this type. When these cutbacks are applied to a road surface or to crushed aggregates in a thin film, the distillate evaporates rapidly, leaving the asphalt cement in practically its original form.†

Cut-Back Products—Petroleum, or tar residue, which have been fluxed, each with its own or similar distillates.*

Cut Back Products—Petroleum, or tar residuums, which have been fluxed with distillates.

Dead Load—The weight of structure, together with fill, pavements and other permanent loads.

Dead Oils—Oils with a density greater than water, which are distilled from tars.*

Deformed Bar.—A steel bar for reinforcing concrete and which has projections on its surface in order to secure a mechanical bond between the concrete and the steel. These projections are formed either by passing the bar through specially shaped rolls or by twisting the bar.

Dehydrated Tars—Tars from which all water has been removed.*

Ditch—The open-side drain of a roadway, usually deep in proportion to its width, and unpaved.*

Double Surface Treatment—This is a term rather loosely employed in different sections of the country to define a method of surface treatment consisting of two applications of asphaltic material followed by a cover coat of mineral aggregate. In some cases, as in the South, it means the original treatment on a road surface of sand-clay, gravel or limerock, where the prime coat is applied and allowed to be absorbed, followed by a seal coat of soft asphalt cement several days afterward, covered with mineral aggregate and rolled. In the southwest and west, double surface treatment might mean two applications of asphalt on a surface which had been primed weeks or months before, each of these two applications being heavy asphaltic material in small amounts, each covered by a mineral aggregate. In still other instances, it might mean two applications of asphaltic material with view to achieving greater thickness of the surface. Accordingly it is not a desirable term to employ because of this variety of meanings.†

Dowels—Metal bars used to connect two sections of masonry.

Dragging—By dragging is meant the easy manipulation of the cover coat under the action of a broom-drag or a wooden drag, so as to distribute the cover coat more uniformly over the surface. Such drags are of varying lengths but it is believed that one twelve to sixteen feet long and having at least three diagonals will usually accomplish the purpose. Before dragging, the roller should pass once over the cover coat to set the bottom stone firmly in the asphalt, after which a combination of rolling and dragging is carried on simultaneously. In addition to the separate broom-drag of sixteen foot wheel base, a section of brooms is frequently set in a frame and attached to either the front or rear end of the roller so as to sweep in advance of the roll.†

Drainage—Provision for the disposition of water. *Side-Drainage*—That along the sides of the roadway. *Sub- or Under-Drainage*—That below the surface. *Surface Drainage*—That on the roadway or ground surface. *V-Drainage*—That provided by the construction of troughs in the sub-grade of the roadway, which troughs are like a "V" with flat, sloping sides, and are filled with stone.*

Drift Punch—A smooth, tapered pin for bringing rivet holes into alignment.

Drop Forged—Forged between dies by means of a drop hammer or drop press.

Drop Hammer (Pile Driving)—One which is raised by means of a rope or cable and then allowed to drop.

Dry Masonry—Masonry laid up without mortar.

Ductility—The physical characteristics of a material which permits it to be distorted without breaking.

Dust—Earth or other matter in fine, dry particles, so attenuated that they can be raised and carried off by air current. The product of the crusher passing through a fine sieve.*

Dust Layer—Material applied to a roadway for temporarily preventing the formation or dispersion under traffic of distributable dust.*

Dust Layers—These are light road oils of low viscosity which may be non-cementitious and which are not expected to form a mat on the road surface. They have high penetrating qualities but are non-volatile, do not develop an asphalt cement and are used only for palliative purposes. Not recommended for any situation where a durable surface mat is desired.†

Earth Road—A roadway composed of natural earthy material.*

Easement or Easement Deed (Right-o-way)—A grant of an indefinite right of use, for a certain purpose, at the will of the grantee.

Emulsified Asphalt—See Asphalt (Emulsified).

Emulsion—A combination of water and oil material made miscible through the action of a saponifying or other agent.*

Emulsion—A combination of water and oily material made soluble through the action of a saponifying or other agent.

End Box—Gussets, shoe cover plates and other details at shoe pins or truss spans.

Expansion Joint—A separation of the mass of a structure, usually in the form of a joint filled with an elastic material, which will provide an opportunity for slight movement in the structure.*

Extrados—The outer or convex surface of an arch.

False Work—Temporary support for a structure during construction.

Fat—Containing an excess. A fat asphalt mixture is one in which the asphalt cement is in excess and the excess is clearly apparent.*

Field Coat—A coat of paint put on steel or other material after or just prior to erection.

Filler—Relatively fine material used to fill the voids in the aggregate. Material used to fill the joints in a brick or block pavement.*

Fillet—A concave junction or molding of two surfaces.

Fixed Carbon—The organic matter of the residual coke obtained upon burning hydrocarbon products in a covered vessel in the absence of free oxygen.*

Flange—A projecting edge or rim.

Flash Point—That degree of temperature at which a given substance gives off vapor in sufficient quantity to flash.

Flour—Finely ground rocks or minerals pulverized to an impalpable product.*

Flow Line—(1) The bottom of a steam bed. (2) The lowest point of the inside diameter of a pipe.

Flush Coat—See *Seal Coat.**

Flushing—(1) Completely filling the voids. (2) Washing a pavement with an excess of water.*

Flux—Bitumens, generally liquid, used in combination with harder bitumens for the purpose of softening the latter.*†

Footway—The portion of the highway devoted especially to pedestrians. A sidewalk.*

Foundation—The portion of the roadway below and supporting the crust or pavement. *Artificial foundation*—That layer of the foundation especially placed on the subgrade for the purpose of reinforcing the supporting power of the latter itself, and composed of material different from that of the subgrade proper.*

Free Carbon—In tars, organic matter which is insoluble in carbon disulphide.*

Gas-House Coal-Tar—Coal-Tar produced in gas-house retorts in the manufacture of illuminating gas from bituminous coal.*

Grade—(1) The profile of the center of the roadway, or its rate of rise or fall. (2) Elevation. (3) To establish a profile by cuts and fills or earth-work. (4) To range by sizes, broken stone, gravel, sand, or combinations of such materials.*

Gram—.0022 of a pound.

Gravel—Strictly defined as waterworn pebbles which will pass a 2½ inch ring and be retained on a 10 mesh sieve but, in general understanding, a mixture of pebbles, sand and small amounts of clay or loam. So-called gravels as used in one section may be entirely different from those similarly defined in other sections. Commercially prepared gravel is to be clearly differentiated from bank-run gravel. In any description of gravel, therefore, it is desirable to indicate the grading (as found by sieve anlaysis), and also to describe the character of the pebbles, such as round, angular, clean, rough, smooth, etc.†

Gravel—Small stones or pebbles usually found in deposits more or less intermixed with sand, clay, etc., but in which mixture, the particles which will not pass a ten-mesh sieve predominate; *gravel clay, gravel sand, clayey gravel* and *sandy gravel* indicate the varying proportions of the finer-sized particles. The differentiation between gravel, sand, silt, and clay, should be made on the following basis:

Size of Particles	Names.
Retained on a 10-mesh sieve	Gravel
Passing a 10-mesh and held on a 200-mesh sieve	Sand
Passing a 200-mesh sieve	Silt or Clay*

Pea Gravel—Clean gravel, the particles of which equal peas in size.*

Grit—Stone, slag, chips, or small gravel free from finer material.*

Gumbo—The natural soil found in certain parts of the middle west, notably Minnesota, the Dakotas, Missouri and Iowa, which are finely divided clays of varying capillarity. Certain gumbos have such low capillarity that, when elevated a short distance above the ground water-level and waterproofed with asphalt, they retain their stability through varying weather conditions to a marked degree.†

Gunite—Mortar placed with a cement gun.

Gutter—The artificially surfaced and generally shallow waterway, provided usually at the sides of the roadway for carrying surface drainage. Occasionally used synonymously with ditch, but incorrectly so, as gutters are always paved or otherwise surfaced, and ditches are not.

Gutter—The artificially surfaced and generally shallow waterway provided usually at the sides of the roadway for carrying surface drainage. Occasionally used synonymously with "ditch," but incorrectly so, as "gutters" are always paved or otherwise surfaced and ditches are not.*

Gusset Plate—A plate connecting two or more structural members not in the same straight line.

Hanger (Through Arch)—A vertical tension member transmitting the load to the arch rib.

Hardpan—A soil which may be either (1) a very dense subsoil, such as tough clay; (2) a cemented layer in the soil, where ground waters have precipitated a local binder of silica carbonates, iron oxides, etc.; or (3) dense clayey glacial drift.

Haunches—The sides or flanks of a roadway. Sometimes called quarters.*

Header—(1) A curb placed across the road at the end of a pavement and set flush with the top of the pavement to hold the end of the pavement in place. (2) A stone or brick laid with its largest dimension at right angles to the face of the masonry.

Highway—The entire right-of-way devoted to public travel, including the sideways and other public spaces if such exist.*

H. O.—Hot Oil—Asphalt of such consistency that it must be heated above 225 deg. F. to be applied effectively.

Hot Oils—Medium to heavy asphaltic road materials, very viscous when cold. They invariably require heating to become sufficiently liquid for application. The term oil in connection with road work is becoming obsolete.†

H. T.—Hot Tar—Tar of such consistency that it must be heated above 175 deg. F. to be applied effectively.

Intrados—The inner or concave surface of an arch.

Invert—That part of a pipe or sewer below the springing line.

Jute—A fibrous, vegetable substance used for caulking

Knapping—Breaking up coarse aggregate by means of hammers or sledges.

Laitance—A thin layer of inert material which collects on the surface of concrete when it is deposited and forms a light chalky crust on hardening.

Layer—A course made in one application.*

Leads—The upright parallel members of a pile driver which support the sheaves used to hoist the hammer and piles, and which guide the hammer in its movement.

Limerock—A material largely found in the southern states and to some extent in the midwestern and southeastern states, having somewhat the same property as caliche but being a much more stable material. It usually is prepared commercially by selection of a given strata in a quarry, containing the right proportion of lime to the other ingredients present. This material is thoroughly ground to a fineness which permits its easy manipulation and consolidation on the road surface.†

Loam—Finely divided earthy material containing a considerable proportion of organic matter.*

Macadam—A road crust composed of stone or similar material broken into irregular angular fragments compacted together so as to be interlocked and mechanically bound to the utmost possible extent.*

Macadams—See Waterbound Macadams and Traffic-bound Macadam.

Mastic—A mixture of bituminous material and fine mineral matter suitably made for use in highway construction and for application in a heated condition.*

Mat—See *Carpet*.*

Mat—A bituminous layer of appreciable thickness, generally formed on top of a pavement by the application of one or more coats of bituminous material with gravel or stone chips added.

Mat Coat—A rather general term employed to describe the surface treatment of a roadway to produce an asphaltic mat over the surface.†

Matrix—A composition or material forming a cushion, or binding the aggregate together.*

Mesh—The square opening of a sieve.*

Metal—See *Road Metal.**

Mix or Mixture—Sometimes used to denote the proportions of the several parts of concrete.

Moisture, Optimum Content—See Optimum Moisture Content.

Mortar—A mixture of fine material such as sand, cement, and water or other liquid suitably proportioned and incorporated together for the purpose for which it is used.*

M. T.—Medium Tar—Tar of such consistency that it must be above 100 deg. F. to be applied effectively.

Mulch Treatment—The method of maintaining a roadbed composed of graded aggregates in smooth riding condition by frequent blading of approximately one inch depth of loose fragments over the surface as a floating cover. This may be done either with the surface treated with light non-curing asphaltic products or in an untreated condition.†

Mush—A greasy mud sometimes found on bituminous crusts.*

Natural Bed—The surface of a stone parallel to its stratifications.

Normal Temperature—In laboratory investigations, 25° Centigrade, which is 77° Fahrenheit.*

Oil Asphalt—Asphalt manufactured directly from petroleum.

Oil-Gas Tars—Tars produced by cracking oil vapors in the manufacture of oil gas.*

Oil Processing—A term used to describe an asphalt roadmix by the graded aggregate method and used widely in the west, particularly in New Mexico. Sometimes confused with surface treatment but, being over one inch in thickness, does not come within this range.†

Oil Treatment—Another variety of the term road oil, which should become obsolete because it is not sufficiently explicit.†

Oiled Gravel—A general term applied to the surface treatment of gravel roads, usually where liquid bituminous materials are employed. Not a desirable term to use, as it is not explicit.†

Oiled Macadam—A general term employed to describe the surface treatment of waterbound or traffic-bound macadam. Not a desirable term and should become obsolete.†

Oils, Residual—See Residual Oils.

Oils, Road—See Road Oils.

Optimum Moisture Content—That percentage of moisture which for any given material produces the maximum stability under traffic. The optimum moisture content varies for every kind of material and for different varieties of the same material, depending on the percentage of voids, the size, shape and surface texture of the particles making up the mixture.†

Ordinate—The perpendicular distance from a point on the tangent to a point on the curve.

Organic—The product of animal or vegetable life.

Palliative—A short-lived dust layer.*

Patching—Repairing or restoring small isolated areas in the surface of the metaled or paved portion of the highway.*

Pavement—The wearing course of the roadway or footway, when constructed with a cement or bituminous binder, or composed of blocks or slabs, together with any cushion or "binder" course.*

Penetration—In laboratory investigations, the distance expressed in tenths of a millimeter, entered a sample by a No. 2 cambric needle used in a machine for the purpose and under known conditions of loading, time and temperature. The degree of solidity of bituminous materials.*

In construction, the entrance of bituminous material into the interstices of the metal of the roadway.*

Penetration—The consistency of a bituminous material expressed as the distance that a standard needle vertically penetrates a sample of the material under known conditions of loading, time and temperature.

Penetration Method—The method of constructing a bituminous macadam pavement by pouring or grouting the bituminous material into the upper course of the road metal before the binding of the latter has been completed.*

Penetration Method—The method of constructing a bituminous macadam pavement by pouring or grouting the bituminous material into the upper course of the road material before the binding of the latter has been completed.

Pile—A member usually driven or jetted into the ground and deriving its support from the underlying strata, and by the friction of the ground on its surface.

Pile Cap—A metal and wood cap placed over the head of a pile to protect it while driving.

Pitch—Solid residue produced in the evaporation or distillation of bitumens, the term being usually applied to residue obtained from tar.*

Pitch, Hard—Pitch showing a penetration of not more than 10.*

Pitch, Soft—Pitch showing a penetration of more than 10.*

Pitch, Straight Run—A pitch run in the initial process of distillation to the consistency desired without subsequent fluxing.*

Plums—Stones or boulders of a volume of more than one cubic foot, incorporated in concrete masonry.

Pocket—A hole or depression in the wearing course.*

Pointing—Filling joints or defects in the face of a masonry structure.

Pot-Hole—A hole extending below the wearing course.*

Precast Concrete—Concrete which is cast into forms and then hoisted and set in place.

Prime Coat—The initial application of a low viscosity asphaltic material to the road surface for the purpose of penetrating, hardening and consolidating all loose particles and to kill the dust, so that the more viscous asphaltic material applied as a seal coat shall be firmly bonded to the underlying roadbed. MC-1 is a satisfactory material for this purpose.†

Profile—A longitudinal section of a highway, generally taken along the center line.*

Profilometer—A machine for recording the irregularities of the surface of the pavement.

Quartering—Dividing a sample of material by thoroughly mixing it and striking it off into four parts. The one-fourth part is again mixed and quartered and so on until the volume is the amount required for testing.

Quarters—The four sections of equal width which, side by side, make up the total width of a roadway.*

Raveling—The loosening of the metal composing the crust.*

Red-Dog—The residue from burned coal dumps. The

dumps are composed of waste products incidental to coal mining, which are not true coal but contain a certain percentage of carbon. Under pressure in the waste dumps, they frequently ignite from spontaneous combustion and the residue is a red-colored ash containing a high percentage of silica with certain mineral salts distributed throughout the mass, which when wetted will form a firm and hard surface.†

Refined Tar—A tar free from water by evaporation or distillation, which is continued until the residue is of the desired consistency, or one produced by fluxing tar residuum with tar distillate.*

Renewals—Extensive repairs over practically the whole surface of the metaled or paved portion of the highway.*

Repairs—The restoration or mending of a considerable amount of the metaled or paved portion of the highway, but not usually of a majority of the surface area. More extensive than "patching," but less so than "renewals."*

Residual Oils—Residual oil is another term for road oil, being the fluid residual product obtained from asphaltic petroleum by distilling off the more volatile constituents.†

Resurfacing—The renewal of the surface of the crust or pavement.*

Rip Rap—Rough stone of various sizes placed compactly or irregularly to prevent scour of water.

Road—A highway outside of an urban district.*

Road-Bed—The natural foundation of a roadway.*

Road Bed—The portion of the roadway extending from shoulder line to shoulder line; in other words, the subgrade and shoulders considered as a unit.

Road Metal—Broken stone, gravel, slag or similar material used in road and pavement construction and maintenance.*

Road Oiling—A general term employed to describe the application of asphaltic products to a road surface. Not sufficiently accurate for the purpose and the term should become obsolete.†

Road Oils—Asphaltic road oils are sometimes crude asphaltic petroleums, but the principal road oils used in road surfacing today are fluid residual oils obtained from asphaltic petroleum by distilling off the more volatile constituents. They are generally described by the amount of so-called asphalt content and are of two general classes—cold oils and hot oils. It is believed that modern practice trends to the use of either cutback asphalts or emulsified asphalts where light treatments are required and the use of soft asphalt cements for heavy treatments, in place of such road oils.†

Roadway—That portion of the highway particularly devoted to the use of vehicles.*

Rock Asphalt—Sandstone or limestone naturally impregnated with asphalt.*

Rock Asphalt Pavement—A wearing course composed of broken or pulverized rock asphalt with or without the addition of other bituminous materials.*

Rocker—A casting supporting the free end of a span, allowing expansion by a rocking motion of the casting.

Rolling—Many specifications prescribe rolling to be done by a certain weight roller, either with three wheels or of the tandem type. In recent years a number of five and seven ton three-wheel rollers have come on the market, as well as the ten and twelve ton sizes. These all accomplish good work under certain conditions. The actual weight of the roller is not the measure of its compacting power but rather the way in which this weight is transmitted through the wheels to the road surface. Accordingly, by rolling is meant the use of a three-wheel roller having a compression of not less than 350 pounds per lineal inch width of roll; except in special cases, such as surfacing sand-clay or topsoil, where a tandem roller is sometimes preferred.†

Rubble—Field stone or rough stone as it comes from the quarry. When it is of a large or massive size it is termed block rubble.

Sand—Finely divided rock detritus the particles of which will pass a 10-mesh and be retained on a 200-mesh screen. Also see *Gravel.**

Sand-Clay—A surface composed of a mixture of sand and clay where the two materials have been blended, so that their opposite qualities tend to maintain a condition of stability under varying moisture content. Some deposits are found in nature, but the bulk of such surfaces are prepared artificially.†

Sand-Clay Road—A roadway composed of an intimate mixture of sand and clay.*

Sandy Gravels—Gravels which contain in their fine sizes silica only, so that even when wet no cementitious characteristics are developed.†

Scarify—To loosen or disturb superficially.*

Screen—In laboratory work, an apparatus, in which the apertures are circular, for separating sizes of material.*

Screenings—Broken rock, including the dust, of a size that will pass through one-half to a three-quarter inch screen, depending upon the character of the stone.

Screenings—Broken stone of a size that will pass through a one-half to three-quarter inch screen, depending on the character of the stone.*

Seal Coat—A final superficial application of bituminous material during construction to a bituminous pavement.*

Seepage—Quiet emergence of water along some rather extensive line or surface, as contrasted with a spring whose water emerges from a single spot.

Setting Up—The relatively quick change such as takes place in a bituminous material after its application to a roadway, indicated by its hardening after cooling and exposure to atmospheric and traffic conditions, as opposed to the slower changes later occurring gradually and almost imperceptibly.*

Shale—A material found in stratified form in nature, of which certain kinds may be a natural sand-clay mixture. Its stability depends upon the proper proportion of sand and the clay in the mixture and also upon certain minerals which have high cementing value, such as ferrous oxide. In general, for a shale to be of first-class quality, the chemical analysis should show not less than 60 per cent silica, 5 to 10 per cent ferrous oxide and *not over 20 per cent of clay,* the remainder being of such materials as magnesium and calcium oxides. Where the clay content exceeds 20 per cent, the shale will be unstable during wet weather conditions.†

Shaping—Trimming up and preparing a subgrade preparatory to applying the first course of the road metal or artificial foundations.*

Sheet Asphalt Pavement—One having a wearing course composed of asphalt, cement and sand, of predetermined grading, with or without the addition of fine material, incorporated together by mixing methods.*

Sheet Pavement—A pavement free from frequent joints such as would accompany small slabs or blocks, and which has an appreciable thickness (say, in excess of one inch on the average) for its wearing course.*

Sheet Piles—Piles driven in close contact in order to provide a tight wall, to prevent leakage of water and

soft materials; or driven to resist the lateral pressure of adjacent ground.

Shell—This type of surfacing is limited to areas near the seashore, where large amounts of oyster and clam shells are available. These shells placed on a road surface and rolled, quickly break up and consolidate into a solid surface, due to a high lime content.†

Shoe—(1) A metal protection for the foot or end of a pile. (2) That portion of a superstructure resting directly upon the abutment.

Shoulder—See Berm.

Shoulders—The portion of the highway between the edges of the road metal or pavement and the gutters, slopes, or watercourse.*

Side Drain—See *Drainage*.*

Sidewalks—The portion of the highway reserved for pedestrians.*

Sieve—In laboratory work an apparatus in which the apertures are rectangular for separating sizes of material.*

Silt—Naturally deposited fine earthy material which will pass a 200-mesh sieve. Also see *Gravel*.*

Skew—The angle which the center line of a bridge makes with a line normal to the center line of the roadway.

Slope Wall—A wall to protect the slope of an embankment or cut.

Slope Stakes—Stakes set to indicate the top or bottom of a slope.

Slump—The vertical distance which concrete subsides from its moulded shape when tested for consistency by the standard method.

Slurry Base—A method of base construction recently developed in the west on a large scale, whereby crushed rock, sand and clay are mixed together in a concrete mixer with water to form a mixture very similar to concrete except lacking in cement. The material is then spread upon a prepared subgrade, finished and rolled, the intent being to obtain a very dense consolidated mixture of stone or gravel with binder material in a more compacted fashion than would be possible by placing the material dry and then adding the filler afterward. Such base construction develops high stability due to its resistance to water and its density. Slurry bases take surface treatments in the same manner as described for bonded surfaces.†

Snow Fence—A structure erected for the purpose of forming artificial eddies on the windward side of a cut at sufficient distance away to cause snow to deposit between the snow fence and the cut.

Soffit—The under or concave side of an arch.

Spall—A chip or small piece of stone from a large block.

Spalls—Fragments broken off by a blow, irregular in shape, and of sufficient size to be comparable to the original mass.*

Span—The distance between the faces of the abutments of a bridge on the center line of the roadway.

Springing Line—The line in which the soffit of an arch meets the skewback.

Squeegee—A tool with a rubber or leather edge for scraping or cleaning hard surfaces, or for spreading and distributing liquid material over and into the superficial interstices of roadways.*

Stone Block Pavement—One having a wearing course composed of stone blocks quite or nearly rectangular in shape.*

Street—A highway in an urban district.*

Stretcher—A stone which has its greatest length parallel to the face of the wall.

Subgrade—The upper surface of the native foundation on which is placed the road metal or the artificial foundation, in case the latter is provided.*

Subgrade Treatment—In reality, the same thing as a blotter treatment, being the method of waterproofing existing earth road surfaces, followed by the application of a thin coat of graded aggregate. Not to be confused with oiled earth.†

Subsoil—The bed of earth immediately beneath the surface soil.

Sump—A well into which water may be conducted by ditches to drain other portions of the work.

Superficial Coat—A light surface coat.*

Surface Coat—See *Carpet*.*

Surfacing—(1) The crust or pavement. (2) Constructing a crust or pavement. (3) Finally finishing the surface of a roadway. (4) Treating the surface of a finished roadway with a bituminous material.*

Surface Treatment—Treating the finished surface of a roadway with a bituminous material.*

Surface Treatment—Treating the finished surface of a roadway with bituminous or other material.

Squeegee Coat—An application by means of a squeegee.*

Sweeping—The vulnerable part of any surface treatment is the outer edge. The presence of loose material between the mat and the underlying surface permits the entrance of water. This loose material must be removed prior to the application of the seal coat, otherwise a spongy place will develop under the asphalt mat. The surface should be swept clean for a width of at least one foot wider than the completed treatment and the edge should be hand-broomed after the rotary-brooming to insure this condition. By sweeping, therefore, is meant the careful and complete removal of all surplus fines from the road surface, using both mechanical and hand-brooming.†

Tack Coat—A term employed principally on the Pacific Coast to describe the initial application of asphalt cement to a previously primed surface, prior to placing the principal amount of cover coat aggregate, in order to insure thorough bond with the old road surface.†

Tailings—Stone which, after going through the crusher, do not pass through the largest openings of the screen.*

Tar—Bitumen which yields pitch upon fractional distillation and which is produced as a distillate by the destructive distillation of bitumens, pyro-bitumens, or organic material.*

Telford—Properly an artificial foundation advocated by Thomas Telford (1757-1820), and consisting of a pavement of stone about eight inches thick, laid by hand, closely packed and wedged together. The individual stones were desired to be about sixteen square inches in section and about eight inches in length. They were set close together on the prepared subgrade, their longest dimensions vertical and on their larger ends, their interstices clinked with smaller stone, and the whole rammed (or rolled) until firm and unyielding.*

Telford—An artificial foundation formed of stone about eight inches thick laid by hand and closely packed together.

Telford Macadam—Macadam with an artificial foundation of Telford.*

Templet—A gauge, pattern or form for testing a surface.

Texture—The structural quality appearing at the surface of the roadbed. When reference is made to nonskid texture, it means that the surface is slightly open with "knobbly" appearance, as contrasted with the perfectly smooth closed surface.†

Top Soil—A variety of surfacing used principally in the southeastern states, being the stripping of certain top-soils which contain a natural sand-clay mixture augmented by grass roots so that the mixture, when placed on a road surface, wetted and puddled under traffic, develops considerable structural strength.†

Toughness—The property of resistance to breaking by impact.

Traffic-Bound Macadam—A surface built up by mixing crushed stone, slag or gravel with the existing road-bed material. In contrast with the waterbound macadam, which is a definite layer with the voids filled with fine material of the same character, the traffic-bound macadam is made stable by filling the voids with the sub-grade material or earth. Such surfaces are more susceptible to water than waterbound macadam, but are more cheaply constructed.†

Tremie—A pipe or conduit having a valve or door on the bottom for placing concrete under water.

Triple Surface Treatment—Another variety of the built-up method of the original treatment on prepared road surfaces, the principle being the application of three grades of crushed aggregate with each succeeding grade of smaller size, calculated to fill the voids in the preceding application. This method is universally recommended for surface treatment with emulsified asphalts.†

Under-Drain—See *Drainage.**

*Up-Keep—Maintenance.**

V-Drain—See *Drainage.**

Viscosity—The degree of fluidity of bituminous materials.*

Viscosity—The measure of resistance to flow of an asphaltic material, usually stated as the time of flow of a given amount of the material through a given orifice. The viscosity of an asphaltic material is one of the most important characteristics and, by defining the limits of viscosity of a product, the exact behavior required on the road for original application is assured. An instrument known as the Saybolt-Furol Viscosimeter is used for this determination.†

Volatile—Applied to those fractions of bituminous materials which will evaporate at climatic temperatures.*

Water-Bound—Bound or bonded with the aid of water.*

Waterbound Macadam—A surface composed of crushed fragments of stone, slag or gravel, where the voids are filled with screenings and dust which are by-products of the crushing, and where a cementing action of the dust in the voids is accomplished by puddling with water. Notwithstanding the frequent assertion that this type of pavement is obsolete, there are many miles being built in the country every year, with excellent results.†

Water-Gas Tars—Tars produced by cracking oil vapors in the manufacture of carbureted water-gas.*

Wearing Coat—The superficial layer of the crust or pavement exposed to traffic.*

Wearing Course—The course of the crust or pavement exposed to traffic.*

Wearing Surface or Course—The course of the pavement exposed to traffic.

Weep Hole—A hole through an abutment or retaining wall for drainage.

Wing Wall—An extension of an abutment wall to retain the adjacent earth.

Wood Block Pavement—One having a wearing course composed of wood paving blocks, generally rectangular in shape.*

Definitions of Contract Terms

From Standard Specifications for Highway Bridges, The American Association of State Highway Officials

Engineer—The chief engineer of the commission acting either directly or through his authorized representatives.

Resident Engineer—The person acting as authorized representative of the engineer in the supervision and inspection of the work.

Inspector—The authorized representative of the engineer or resident engineer, assigned to make a detailed inspection of any or all portions of the work, or materials therefor.

Contractor—The individual, firm, or corporation undertaking the execution of the work under the terms of the contract and acting directly or through his or its agents or employes.

Specifications—All provisions and requirements contained herein, together with all written or printed agreements and instructions, made or to be made pertaining to the method and manner of performing the work, or to the qquantities and qualities of the materials to be furnished under the contract.

Instructions to Bidders—All instructions, issued for the information of bidders, pertaining to the requirements governing the submission of proposals, the quantities and qualities of materials, the performance of the work and payment thereof.

Contract and Included Documents—The agreement covering the performance of the work as provided in the specifications. The contract includes the advertisement, instructions to bidders, proposal, contract and contract bond, these specifications, supplemental specifications, general and detailed plans, all supplemental agreements entered into, and all general or special provisions pertaining to the work or materials therefor.

Proposal Guaranty—The security designated in the instructions to bidders or proposal, to be furnished by the bidder as a guaranty of good faith to enter into a contract for the work contemplated if it be awarded to him.

Surety—The individuals or corporate body which is bound with and for the contractor, for the acceptable performance of the contract, and for his payment of all debts pertaining to the work. Where applying to the "Proposal Guaranty" it refers to the individuals or corporate body which engages to be responsible for the bidder's acts in the execution of a satisfactory contract in the event of it being awarded to him.

Right of Way—The area designated by the engineer for use in constructing the structures covered by the contract, including the appurtenances thereto. The right of way so designated may be either temporary or permanent.

Roadway—The portion of the right of way reserved for traffic.

Temporary Structure—Any temporary structure or stream crossing required to maintain traffic while constructing or reconstructing structures, or parts of structures covered by the contract. The temporary structure shall include the earth approaches thereto.

Substructures—All of that part of the structure below the bridge seats or below the skewbacks or arches, except that backwalls, wingwalls and wing protection railings shall be considered as part of the substructure.

Superstructure—All of that part of the structure above the bridge seats or clearance line, or above the skewbacks of arches, except as noted above.

Patented Types and Copyrighted Names of Pavements

Messrs. Brown and Connor, in their treatise on low cost roads and bridges, have compiled the list of names which is reproduced herewith. In connection with it they say:

"Included under this heading will be mixing methods, mixing equipment, sold under trade names, and trade named bituminous materials. It is not necessarily understood, nor is it true, that these types can be classed entirely as low-cost road types. Because this glossary is included in this book it does not follow that we do or do not recommend any of the types. The glossary is included primarily to give the reader a general idea of the method of mixing or material under discussion. It is probably true that the most of the proprietary types discussed here fall without the pale of a discussion on 'Low Cost Roads and Bridges.' Were it not for the fact that salesmen for these types endeavor to promote them to public bodies in competition with one another and with low cost types they would not be discussed here. Some of the types described have made good pavements. Others have not been so good. The engineer must investigate each product or method to greater extent than is given herein before passing judgment on it."

Agrolith.—This patented process consists of double coating the aggregate, first with a hard bitumen, then, after cooling, with a softer bitumen. The prepared material is a hot-mix cold-lay type, especially for sheet asphalt gradings. Compaction is obtained by a roller rather than by traffic. It is claimed by the promoter that with any grading of any type aggregate, a satisfactory surfacing material can be produced.

Altapave.—Manufacture consists of passing raw sands of the Alberta Tar sand deposits through process which eliminates the light oils, bringing materials up to a standard and fixed percentage of asphalt. Material is then compressed into brick or slab form, and powdered with sandstone dust. Sands are found in the deposits at McMurray, Alberta, Canada.

Amiesite.—Broken rock is placed in a mixer and intermingled. The specified quantity of a liquifier which may be any mineral oil, such as kerosene, gasoline, crude naphtha, or volatile petroleum distillate, is then sprayed into the mixer, coating the surfaces of the rock.

Amiesite asphalt cement at a temperature of between 250° and 300° F. is then poured into the mixer so as to coat all of the stone. The mixing continues until the mass presents a uniform black color. Hydrated lime is then added to the mix and mixing continues until the uniform black color again appears. The mineral filler is finally added in such a way that the particles are uniformly spread throughout the mass. The batch is dumped as soon as the mineral filler has thoroughly adhered to the asphalt coated aggregate. Both bottom layer (of coarse rock) and top layer (finer rock) mixtures arrive on the work cold. These mixtures are deposited outside of the area in which they are to be laid. The layers are then spread in a loose condition one over the other and are compacted simultaneously by rolling. The surface is sealed with a top dressing.

Alabama Asphaltic Limestone.—The asphalt contained in the pores of both the Alabama and Texas asphaltic limestone is hard. The penetration of that found in the Alabama rock is about 20. The bitumen content of the Texas rock is shipped as around 9 to 11 per cent. The Alabama product contains from 4 to 6 per cent bitumen when shipped. Both of these materials, of course, must be fluxed to provide a film of bitumen around the aggregate that is soft enough to prevent cracking and is in sufficient quantity to bind the particles together. Too little bitumen results in a mixture that is hard to compress and therefore is not durable.

Tests indicate that with this material, safe stability, to carry the heaviest traffic, is secured when an added asphalt of 85 to 100 penetration is used in sufficient quantity for the total "recoverable" asphalt to fill the voids. By "recoverable" asphalt is meant the bitumen that can be extracted from the crusher-run rock asphalt plus the added bitumen.

Amulco.—This is the trade name of a bituminous emulsion. Like other emulsion manufacturers, the company produces various grades for the various uses in road work. The manufacturer claims that it was not until the introduction of the Amulco processes and materials that fine materials could be used successfully in mixtures with emulsified asphalt.

Asbestophalt.—This product is a standard stone-filled sheet asphalt mixture in which asbestos fiber had been substituted for the limestone dust or filler. The mix is composed of proportionate parts of crushed rock, sand, asbestos fiber and asphalt cement. The material is mixed hot, at an asphalt plant and hauled in trucks to the roadway where it is laid at 325° to 400° F. Extracted bitumen in samples showed content to be 12.3 per cent of 57 penetration asphalt.

Azrock.—This is the trade name for a group of products marketed by a Texas rock asphalt producer. Natural bituminized limestone rock is quarried, crushed and pulverized to a fine grading.

Characteristics of the crushed rock are similar to the limestone deposits of Alabama except that the Texas rock has about 10 per cent asphaltic content. The material is laid cold. Sometimes emulsified asphalt, in small quantities, or asphaltic road oils are mixed with the finely ground rock asphalt before it is laid.

Bitucote.—This is the name applied to a series of stable emulsified asphalt products all of which are designed for the particular purpose for which they are intended. They are liquid compounds of proper penetration asphalt finely dispersed in water, being stabilized with various amounts and kinds of emulsifying agents, depending on the desired use. In certain refined and modified forms they are used for protective coatings for exposed surfaces: on bridges, etc. They are used for water and damp proofing.

In temperatures above freezing these products are used cold. They are not injured by freezing prior to use.

Bit-U-Crete.—This is a bituminous concrete prepared from a stable emulsion. The ingredients of the mix are weighed out and voidage reduced to a minimum. Clay or a similar mineral filler is used in making the stable emulsion.

Bitumuls.—This is an asphalt emulsion prepared according to the manufacturer, by employing a "seed" from a former batch in place of a soap solution for the emulsifier. This, while it may be true in a sense, is not the whole story because an alkali water is used which forms a saponified emulsifier in the process of dispersing the asphalt throughout the water. Practically the same claims are made by the manufacturers of Bitumuls as are made by manufacturers of other emulsions.

Bituroc.—This type paving generally falls in the high type construction. It is mined from natural Kentucky silica sandstone deposits containing varying amounts of bitumen from 0 to 12 per cent. It is quarried and crushed

to fineness of sand grains and the bitumen content controlled to about 7 to 9 per cent by mixing leaner and richer sandstone mixtures as needed.

Bitusprink.—A chemically treated liquid asphalt or tar compound containing not less than 50 per cent bitumen, which will mix with a chemically treated hard water in any proportion without noticeable separation, breaking or clotting. It is used as a dust preventative. Water is placed in a tank, the water compound added and stirred, then Bitusprink, in the proportion desired, is added to the treated water and given a slight stirring. The emulsion is then ready to spray on the road.

Colas.—This is another emulsion of asphalt in water. Soap is the emulsifying agent. The asphalt is a medium soft straight run Mexican asphalt. The manufacturers claim that when Colas breaks, the water and dissolved emulsifying agent run off or evaporate. Colas specifications call for a layer of sand over the base first before the aggregate is placed. In rolling, the sand works up through the aggregate from the bottom. Chips are spread for the seal coat and the entire mass rolled more. Colas was introduced here from England. It is made in several grades for use under certain conditions.

Colprovia.—The Colprovia process consists of coating the aggregate with a non-volatile prepared asphaltic softening medium in a twin-shaft pug-mill or other suitable mixer and then introducing a hard asphalt in powdered form which forms a film over the particles to prevent their sticking together. The proportions of flux oil and powdered asphalt may be varied to produce any penetration cement commonly used. At atmospheric temperatures and pressures the solution of the hard in the soft asphalt is very slow but at increased temperatures or rolling pressures becomes more rapid. It can be shipped by rail in gondola cars and unloaded with a clam-shell bucket or stock piled. Upon rolling it starts to harden and the work may be opened to traffic as soon as rolled. The surface of sheet types can be planed like rock asphalt only during the first day or two after rolling.

Standard sheet, stone-filled sheet, Topeka top, asphaltic concrete, binder, and black base mixtures are all readily made by the Colprovia Process. This process was invented in England and perfected in America.

Crown Rock.—This is essentially a hot mix, cold-lay sheet asphalt wearing surface. The materials are fine crushed gravel graded, fine crushed limestone graded, fine crushed air cooled slag, blown asphalt, fluxing asphalt, and flux oil. The product is manufactured under the Downard Process patents. The crushed gravel aggregate is dried in a standard drier and mixed with about 6 per cent of blown asphalt. After being mixed, it is fed onto a belt and run through a tank of water and thoroughly cooled. The crushed limestone is dried in a standard drier, mixed hot (about 250° F.) with a fluxing asphalt (Furol viscosity, about 270 seconds at 200° F.), then run into a blender where it is thoroughly blended with the coated, cooled, crushed gravel aggregate in equal proportions. This material is then stock piled or shipped in open top gondolas or trucks.

The flux oil is used to render the fluxing asphalt less viscous if the air temperature is below 60° F.

The prepared fine material is then laid, spread, and rolled to form a one course surface.

Dillonite.—This patented type is made from any aggregate which need not be free from clay. Sodium hydroxide in a 2 per cent solution is sprayed onto the dried aggregate in the mixer. The patent claims that when this is done the NaOH forms the clay into balls and they harden. The patent also claims that the 10 per cent of asphalt, which is next added, adheres better to the aggregate in the presence of the alkali solution. The mixed material is then hauled onto the road, raked, and sealed after being rolled.

Duraco.—This is a Texas rock asphalt like the Alabama product. It is about 75 per cent rock asphalt, and 5 per cent trap rock with a small amount of flux oil and other ingredients added to make the mixture easy to handle. It can be laid either hot or cold depending on the bitumen fluxed with it. Aggregates may also be mixed with it. The function of the added trap rock is to make the material shipable and the pavement nonskid.

Flint Falt.—Flint Falt is a bituminous concrete made from a stable asphalt emulsion. To it is added Joplin flint or similar hard stone, which is graded in size to leave the lowest percentage of voids. It is shipped in open top coal cars from a plant at Webb City, Missouri. The minimum shipment is 35 tons.

Headley.—This is one of the first asphalt emulsions manufactured in America. It is a soap emulsion prepared from straight steam distilled Mexican asphalt. Various grades are manufactured for various purposes. It is claimed that their emulsion, Viafalt, is not injured by freezing. Like other emulsions, Headley products are not heated for application.

Interaco.—This is a mixture of definitely proportioned mineral aggregates, bituminous solvent, soft bitumen, bituminous filler, and supplementary mineral filler. The solvent is mixed with an oil asphalt with a softening point of 40° to 60° C., and penetration of 60 to 110 at 25° C., 100 g., 5 seconds. The bituminous filler is a blown asphalt of 170° to 230° C., softening point and a penetration of 10 to 60 at 27° C. The seal powder is a mixture of 20 per cent by weight of blown asphalt of 10 to 25 penetration and 80 per cent mineral aggregate smaller than the 10-mesh sieve. The mixture is laid cold after being mixed in a close blade pug-mill.

Kyrock.—Similar to Bituroc described above. It is quarried from a natural silica bituminized sandstone deposit in Kentucky. As in other asphalt construction repairs, the surface of an old base is painted with a liquid bitumen prior to placing rock asphalts.

Lincolnite.—This is a finely pulverized hard asphaltic compound of high melting point. When placed on the road in contact with soft asphaltic oils it fluxes with the oil and forms a mat on the surface of the road. The powder is pulverized to pass the 100 mesh sieve. It may be shipped in bags without hardening or compacting. Dusting the surface of a freshly oiled road with this material makes it possible for cars to drive over the road immediately without picking up the aggregate. The powder is spread with a lime spreader at the rate of ½ to 1 pound per square yard.

Lincoln road oils are also produced by the same manufacturer.

Macasphalt.—In the process of manufacture an asphalt cement is made by blending together hard natural Cuban asphalt with a petroleum flux (topped Mexican crude). The blending is done at a temperature not over 230° F. The powdered asphalt and flux are placed in steam heated kettles with revolving blades. The proportions of asphalt to flux are such as to give a cement of about 200 penetration.

In preparing a pavement the aggregate is heated and dried in a standard asphalt plant. If over 150° F. it is passed through cooling driers until brought down to that temperature. If it is desired to store the material, two or three quarts of water are thrown into the pug-mill just prior to dumping the batch. Addition of water fluffs up the material so that it is more easily raked. Laying on street is done by same methods as are employed for hot mix pavements.

It is one of the earliest types of cold laid sheet asphalt mixtures and is generally made with well graded sheet asphalt aggregate.

Penolithic.—Penolithic is a patented asphaltic type pavement, the patent rights of which are controlled by Warren Bros. Co., Boston, Mass. Penolithic wearing surface course is constructed upon the base prepared as specified by Warren Bros. Upon the prepared base course a layer of stone, coated with a penetrating oil, is rolled to the approximate thickness of the finished surface course and treated with hot asphalt cement. The surface voids are then filled by applying and rolling in sufficient oil coated stone of intermediate size; a seal coat of hot asphalt cement is applied and covered with fine stone or coarse sand. This type of pavement is in the nature of intermediate construction between penetration macadam and the familiar Warrenite Bitulithic pavement.

The penetrating oil used is cold-applied, non-volatile, and limpid oil. Hot asphalt should follow the oil coat in about a half hour.

Penotread.—This is a variation of the above designed for surface treatments of light traffic.

Plant Mix.—This is a bituminous product manufactured at Joplin, Missouri.

Plant Mix is a product containing cut-back asphalt, Joplin flint chat, Carthage limestone and lime dust as a mineral filler and is manufactured at a plant at Webb City in three grades; namely, 1, 2, and 3.

Grade No. 1 contains a maximum size of 1½ in. flint, flint sand and mineral filler (lime dust) and is used as a base course on gravel or broken stone surface.

Grade No. 2 contains a maximum size of ½ in. flint chat, flint sand and limestone (mineral filler) and is used as a second course, but chiefly used for resurfacing and patching brick, concrete, asphalt or other hand surface streets or highways.

Grade No. 3, seal coat, contains flint sand and limestone (mineral filler) and is used for sealing No. 1 or No. 2 grades, but can be used for resurfacing by itself. This material has the appearance of sheet asphalt. It is laid cold and can be used without heat, except in extremely cold weather. It should not be placed while raining, and the subsurface should be primed with a light application of bituminous primer before the placing of the plant mix. It is raked and rolled in much the same manner as a hot mix asphalt, care being taken not to over rake, as it may cause a wavy finish. Laboratory control is kept on all asphalt and aggregatees during production at the plant.

Pre Cote.—The cold laid mix known as Pre Cote is a coarse aggregate plant mix prepared in a Pre Cote patented plant. In the manufacture of this product, the aggregate is immersed in an emulsion prepared on the job by the Pre Cote portable emulsifier. A bucket elevator with perforations in the bottom of the buckets dips into the emulsion vat, picks up the aggregate from which excess emulsion drains as it goes to a hopper. The excess emulsion flows back into the vat. Any desired viscosity of emulsion may be prepared by the emulsion machine. Water is softened on the job as it is required.

Either tar or asphalt emulsions may be prepared.

Saturmix.—This is a plant for coating coarse aggregates. The unit operates on the immersion principle. Aggregate is dropped into a vat within which is a perforated container submerged in the vat of bitumen. After aggregates are dropped into this, the perforated container rotates out of the vat, dropping the coated aggregate into a hopper, the bottom of which is perforated so that excess bitumen may drain off and run into a collecting tank to be used again.

Slagmac.—This surface consists of a two course pavement in which slag is used as the aggregate and an especially prepared, refined coal tar is used as the bitumen, the material being laid cold. Samples analyzed show extracted bitumen in the base course to be 4.4 per cent and in the surface course to be 6.0 per cent. The pavement is laid with a seal coat.

Tarmac.—This pavement is laid in two courses, a base and a surface course. The aggregate in the base course is graded from 1½ in. to ¼ in., and the surface course from ½ in. to No. 10. The bituminous binder is specially prepared refined tar. This mix is laid cold.

Tarvialithic.—This is a hot-mixed, cold laid, refined tar product manufactured in three grades. It has been discussed quite fully in Chapter V.

Warcolite.—This is a cold laid mixture which is prepared in a standard asphalt plant. Warcolite solution is added, of course, before the batch leaves the mixer. It is a tempering agent which, theoretically, forms a thin film over the bitumen coated mineral aggregate. It prevents agglomeration until the mass has been spread on the roadway and rolled.

Westphalt.—Westphalt is a stone filled asphaltic mixture. It consists of a hard, properly graded mineral aggregate composed of such materials as stone screenings, broken slag, fine tailings, crushed and uncrushed gravel, and sand uniformly mixed with a mineral filler, and unblended asphalts so proportioned that when blended by heating the mixture just prior to laying, a true asphalt cement having correct physical and chemical properties is formed therein, binding the mineral aggregate together. The material Westphalt is shipped as a loose, uncompacted granular mixture prepared at centrally located plants and shipped in open top freight cars or delivered in trucks and may be carried in stock piles as long as desired.

It is heated on the job to 250 or 275 degrees F. just prior to laying, but when being prepared before shipment, it is mixed cold.

The producer states that the mix is composed of aggregate combined with hard Gilsonite in a powdered state, and a fluxing oil. While in a cold state the fluxing oil and Gilsonite will not combine.

There may be and probably are other types of patented materials or processes. Those listed above are the types which have come to the attention of the authors.

Willite.—This surface is laid in two courses. The base is prepared from a coarse graded aggregate while the surface course is prepared from finer aggregate between the No. 8 sieve and ½ inch screen. The bitumen is a cut-back asphalt with an admixture of copper sulphate.

Intent of the Plans and Specifications

The true intent of the plans and these specifications is to provide for the erection and completion in every detail of the work described herein, and it is understood that the contractor for all or any part will furnish all labor, material, equipment, tools, transportation and necessary supplies, such as may reasonably be required to execute the contract in a satisfactory and workmanlike manner and in accordance with the plans, specifications and terms of the contract. Any deviation from these requirements must be stipulated in the contract.—*From Standard Specifications for Highway Bridges and Incidental Structures, The American Association of State Highway Officials.*